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Heavy-Oil Engines: Their Evolution and Types

Some Significant Facts About a Class of Prime Movers That is Rapidly Growing in Favor and in Scope of Application

By L. V. ARMSTRONG

THE heavy-oil engine has been employed in this country for the better part of a quarter of a century. Engines of this type, installed as far back as 1902, are still operating and giving reasonably good service. When it is recalled that Dr. Rudolph Diesel took out his first patents as recently as 1892, and that the first commercial engine of this type was not built until 1898, it becomes evident that the operating engines just referred to are probably somewhat crude in design even though they may be performing well enough for their owners to keep them on the job. It has been only within the last seven years that the Diesel engine has won for itself widespread favor.

In industries where the raw material represents only a small part and labor and power constitute the major part of the manufacturing costs—such, for instance, as municipal lighting, water pumping, quarrying, etc.—the Diesel engine became popular well-nigh overnight. In other industries—those that handle expensive raw products, the transition has occurred more slowly but it has taken place, nevertheless.

Another factor which has influenced the selection of oil engines has been the several bad coal strikes with which the public has had to contend in the last few years. Labor plays a very small part in the production of petroleum and in its delivery to the consuming plant. The real reason, however, for the growing popularity of the Diesel engine has been its economy combined with the fact that keen competition has made operating economy of prime importance. Much has been said about this economy, but usually it has been expressed in terms of pounds of fuel per brake-horse-power hour, which is not illuminating to a person unfamiliar with the several factors involved.

The man that is engaged in pumping water wants to know what the fuel cost is going to be per 1,000 gallons pumped; the contractor wants to know what it will be per 1,000 cubic feet of air delivered; the power-plant owner wants information upon the outlay per kilowatt-hour delivered at the switchboard; and the man that runs an ice plant wants to know what he will have to pay for each ton of refrigeration or for each ton of ice manufactured. Costs could be given for any of the foregoing activities—costs, mind you, obtained from plants in actual operation; but let us confine ourselves to a single industry in order to avoid confusion. We shall take that of the ice manufacturer; and, at the start, it should be understood that the results obtainable will be largely governed by the type of plant and by the operating pressures employed.

IN numerous directions, power-plant engineers are giving study to the oil engine with the idea of applying it to their problems. Even so, comparatively few people save those engaged in the manufacture of this type of prime mover realize how widely and in how many different services these engines are used today.

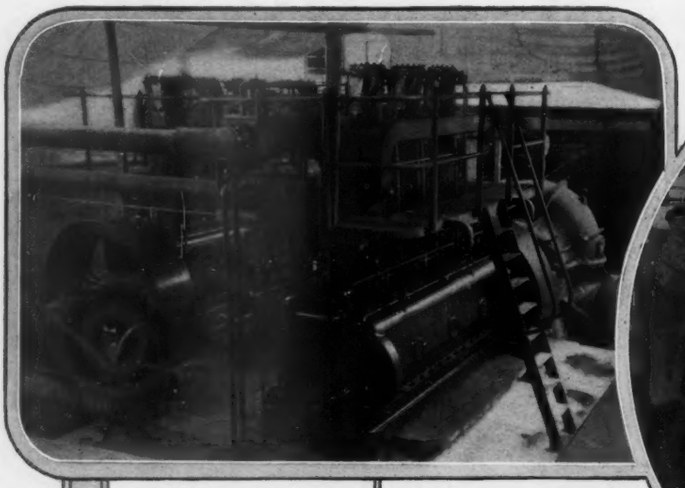
The oil engine has won its way quietly to recognition, and its success has in a large measure been blanketed by the publicity enjoyed by the ever-present gasoline motor. The purpose of the accompanying article is to reveal the true merits of the heavy-oil engine and to lay proper stress upon its distinctive characteristics.

We shall consider an acceptably efficient installation having sufficient condensing surface and using an ample supply of water at a temperature of 70°F. At pressures of 20 and 185 pounds, the cost of fuel and lubricating oil per ton of ice produced is 24 cents, with fuel oil costing 6 cents a gallon. At pressures of 20 and 150 pounds, the cost of fuel and lubricating oil per ton of ice is 19½ cents—the price of the fuel still being 6 cents a gallon. The foregoing costs include not only the compressor but also the auxiliary load. Now, 6 cents is a high figure for fuel. It can be purchased for about 4½ cents under present market conditions, so that the charge of 6 cents a gallon is excessive and, therefore, makes the production figures high or conservative, whichever way one chooses to express it.

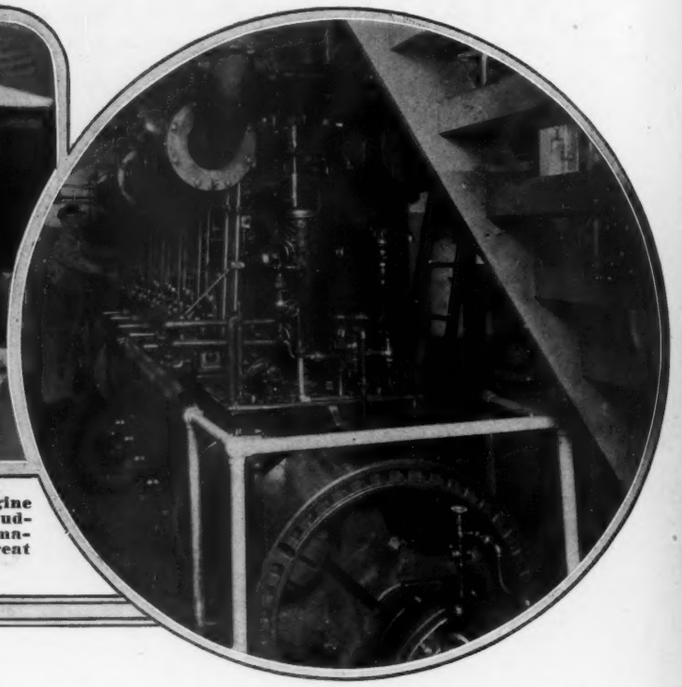
There is a widespread tendency to look upon the Diesel engine as something mysterious and fairly beyond human comprehension. This attitude is unwarranted, and may be disproved by comparing the heavy-oil engine with the more familiar internal-combustion engine, which uses gasoline for fuel.

For each cylinder of a gasoline engine there are the following features: a cylinder and head which are water jacketed to prevent them from becoming too hot; a piston, with rings, to maintain compression; a wrist pin; a connecting rod; a crank pin; a crank shaft; main journals; main bearings; housing; a bedplate; and a flywheel. To these must be added a lubricating system for the rotating and the sliding surfaces. If the engine operates on a 4-stroke cycle, there are: a cam shaft, cams, push rods or rocker arms, and an intake and an exhaust valve for each cylinder. If the engine is of a 2-cycle type, it must have exhaust ports, scavenging ports, and some kind of a system for furnishing low-pressure air for scavenging.

We thus see that the Diesel engine does not differ in any essential respect from the gaso-



Two 300-H.P. Ingersoll-Rand oil engines driving Cameron pumps in a Texas water-improvement district.



This 220-H.P. oil engine of the ferryboat Hudson-Athens can be maneuvered with great ease.

line engine. The heavy-oil engine has all the parts mentioned, and they are similar in design to those for the gasoline engine. To take care of the higher pressures and the higher temperatures which are developed in the Diesel engine, its various parts are made correspondingly heavier. In the gasoline engine the fresh charge of air is drawn through the carbureter which contains gasoline; and because gasoline is volatile the air carries with it into the cylinder a quantity of gasoline vapor. This mixture of gasoline and air is compressed in the cylinder by means of the piston; and when the piston has reached somewhere near top center the compressed charge is fired by an electric spark.

In the Diesel engine the fuel is an oil which does not easily vaporize, and another system must be employed to get the fuel into the cylinder. Accordingly, air alone is drawn into the cylinder and compressed. A few degrees before top center, the fuel oil is injected in the form of a fine spray which closely approximates a vaporlike state. It should be pointed out that the air for combustion is compressed much more highly in a Diesel engine than in a gasoline engine. In fact, the temperature resulting from compression is about 1,000°F.; and when the sprayed fuel meets this heated air the oil begins to burn and continues to burn during the entire injection period. Therefore, the Diesel engine differs materially in two respects from the gasoline engine—namely, in the method of getting the fuel into the cylinder and in the method of igniting the fuel.

While the means by which the fuel is delivered to the cylinder are somewhat more complicated in the case of the Diesel engine, this complication is more than offset by the fact that only the heat of compression is needed to ignite the charge. In other words, the heavy-oil engine does not require a magneto or a storage battery, nor a timer, spark plugs, and connecting wires. It is not necessary to emphasize that many of the troubles in the working of a gasoline engine may be traced to faults in the ignition system; and the Diesel engine is a simpler and a better machine because of the absence of such a cause of worriment.

The solid-injection, airless-injection, direct-injection, mechanical-injection engine—as it is variously called—is an American development. The original Diesel patents did not contemplate the use of high-pressure air but simply covered a new form of heat cycle. Any engine which follows this heat cycle may properly be termed a Diesel engine. The use of high-pressure air was adopted because of the difficulty experienced by early designers in introducing the fuel oil into the cylinder at the rate and in the form needful to obtain the Diesel cycle.

In the solid-injection oil engine the 3- or 4-stage air compressor, with its intercoolers, aftercoolers, mechanically operated injection valves, injection valve cams, and high-pressure piping, has been done away with. In place of these parts has been substituted a very simple form of plunger pump with spray nozzles at the cylinders. In appearance, the spray nozzles somewhat resemble the burners employed in some mechanical fuel-oil burning systems for boilers.

Just as with gasoline engines, oil engines may be either of 2-cycle or 4-cycle types; and oil engines are also classified as Diesel or semi-Diesel machines. To be specific: A Diesel engine is one of high thermal efficiency—that is, it has high fuel economy, and the heat of compression is sufficient to ignite the fuel charge without heat from an extraneous source either

Sixty-ton, oil-electric locomotive climbing an 8 per cent. grade.

DIVERSITY OF APPLICATION OF OIL-ENGINE POWER PROVES RELIABILITY AND ECONOMY OF THIS TYPE OF PRIME MOVER

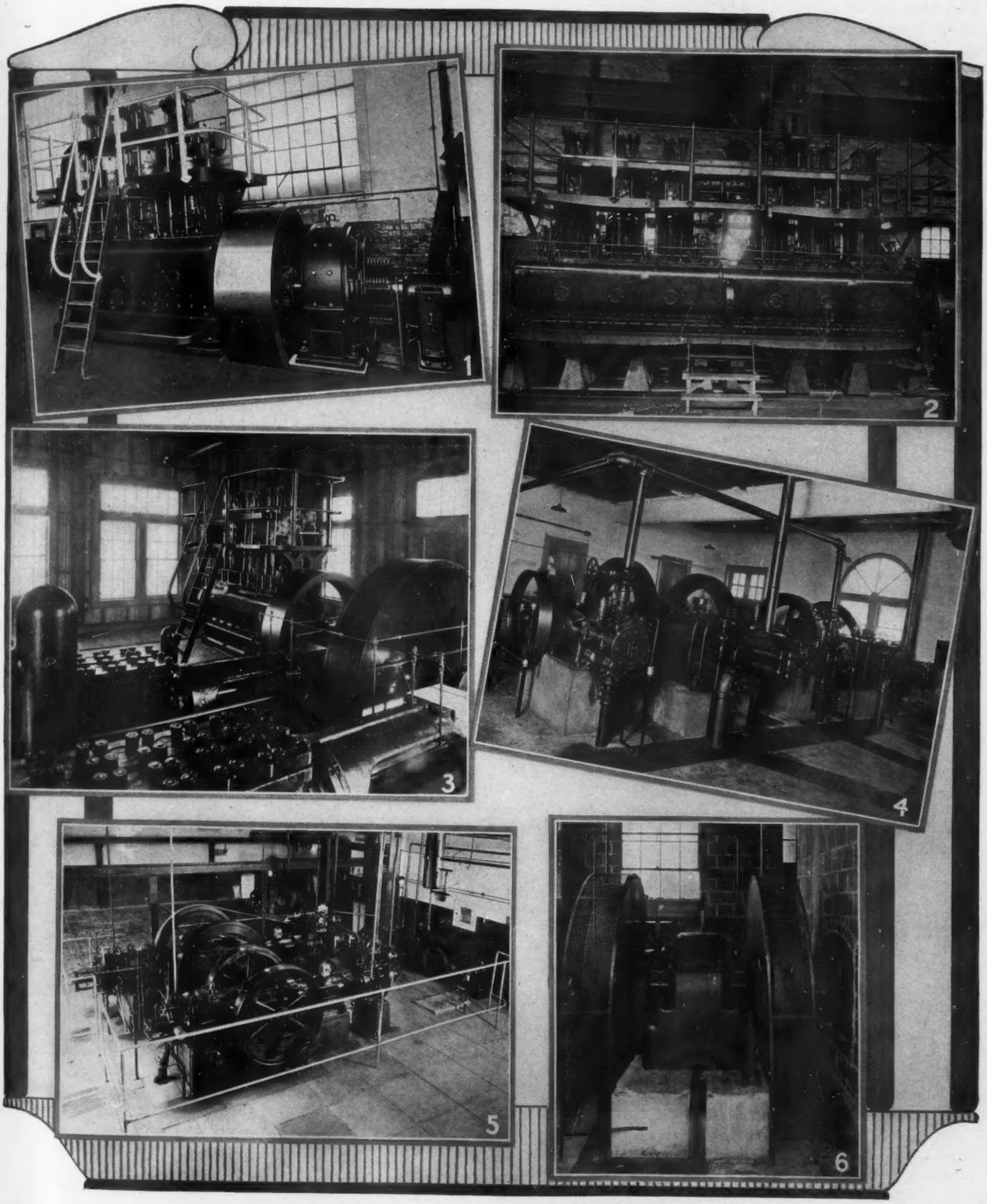
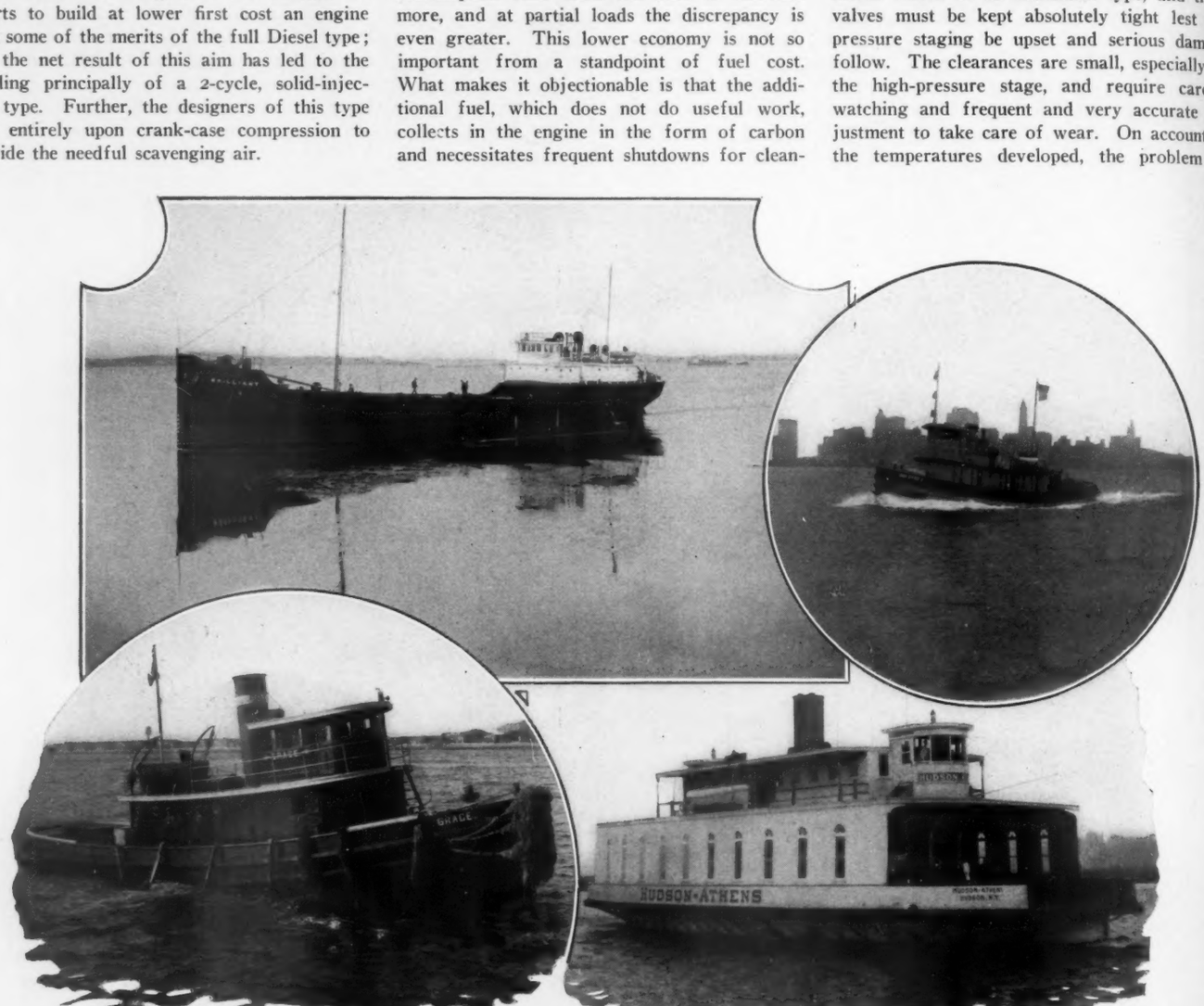


Fig. 1—Oil-engine generator set installed in a large industrial plant.
Fig. 2—Six-cylinder oil engine which replaced a steam engine in a big Western flour mill.
Fig. 3—Pipe-line pumping—a splendid field for oil engines.
Fig. 4—Oil engines driving air compressors and centrifugal pumps in a municipal water plant.
Fig. 5—Direct-connected oil-engine ammonia compressors are the cheapest source of power for the ice and refrigerating industry.
Fig. 6—Oil engine direct connected to a pump in an Eastern oil refinery.

when starting or during operation. Starting in this manner is what is commonly known as "cold starting." An engine of this kind will deliver from seventeen to twenty brake-horsepower hours per gallon of fuel oil.

The semi-Diesel engine is the outcome of efforts to build at lower first cost an engine with some of the merits of the full Diesel type; and the net result of this aim has led to the building principally of a 2-cycle, solid-injection type. Further, the designers of this type rely entirely upon crank-case compression to provide the needful scavenging air.



Some of the varied marine installations of Ingersoll-Rand solid-injection oil engines. The tug "Grace" is driven by a 220-H.P. directly reversible oil engine. The tanker "Brilliant" and the "Van Dyke III"—one of three identical tugs—are each equipped with two 225-H.P. oil engines direct connected to generators furnishing current to a 370-H.P. propelling motor. These engines are of the same type as the three 840-H.P. engines recently installed in the converted tanker "J. W. Van Dyke." The ferryboat "Hudson-Athens" is propelled by a 6-cylinder, directly reversible, 220-H.P. oil engine.

Inasmuch as the initial compression of a semi-Diesel engine does not raise the temperature high enough to ignite the fuel either when starting or during operation, this is overcome by making part of the cylinder head nonwater-cooled. This uncooled part may have the form of a bulb, a plate, or a tube. Before starting, this bulb, plate, or tube is heated red-hot by means of a kerosene blow torch. The heat thus localized, plus the heat obtained by compression, suffices to start the engine. After the engine has started, the heat generated by combustion keeps the uncooled surface hot. When running with a small load, the heat obtained from the impulse explosions is sometimes not sufficient to keep the bulb, plate, etc., hot; and when this is the case a blow torch is resorted to to prevent the engine from misfiring or, possibly, stopping.

The fuel consumption is not nearly so good as for a full Diesel engine. At rated load, the consumption runs from one-third to one-half more, and at partial loads the discrepancy is even greater. This lower economy is not so important from a standpoint of fuel cost. What makes it objectionable is that the additional fuel, which does not do useful work, collects in the engine in the form of carbon and necessitates frequent shutdowns for cleaning out. This, in turn, means fewer working hours and a correspondingly reduced earning capacity.

Crank-case compression imposes a higher consumption of lubricating oil. A semi-Diesel engine will use from two and a half to five times as much lubricating oil as a full Diesel engine. As a primary source of power in a machine shop, or in some other kind of plant where continuous and reliable service is not an essential, a semi-Diesel engine will be found a good and a cheap source of power.

Now let us consider the relative advantages of the compressed air and the solid-injection types of Diesel engines. A compressor capable of delivering air at 1,000 pounds pressure—such as is used for injection purposes—is a complicated and delicate machine; and to be safe, the compressor should be built to operate at three or, preferably, four stages. A 3-stage compressor will have not fewer than eleven valves of an automatic type, and these valves must be kept absolutely tight lest the pressure staging be upset and serious damage follow. The clearances are small, especially on the high-pressure stage, and require careful watching and frequent and very accurate adjustment to take care of wear. On account of the temperatures developed, the problem of lubrication becomes an extremely delicate one. If too much lubricating oil is used an explosion may occur, and if too little oil is used the disastrous consequences of under lubrication are invited.

An intercooler is required between the low and the intermediate stages as well as between the intermediate and the high stages. Also, an aftercooler should be interposed between the high stage and the air flasks which supply the air directly to the cylinders. These aircoolers are not particularly troublesome but they do represent additional equipment which must be taken care of. Connections in the 1,000-pound air line call for continual attention.

The solid-injection oil engine does not re-

quire the services of a high-pressure compressor; and because of this there is a saving in weight, in space occupied, and in first cost.

It is possible to utilize the oil engine for power-plant work in a number of ways; and probably the most common is the use of the oil engine as a prime mover for electric drive. An oil-engine generator set or sets may be installed advantageously where anyone of the three following conditions prevails:

(a) In an existing plant, where the equipment is already motor driven.

(b) In a new plant, where the equipment is spread over a considerable area and operates either at different or varying speeds.

Solid-injection, heavy-oil engine of 300 H.P. in the plant of a Louisiana salt-mining company. Another engine of the same type, but of 400 H.P., has recently been added to this plant.

(c) In a new plant, where the aggregate of horse-power for all equipment is large but where the peak load is smaller than the aggregate horse-power and where the average load factor is smaller than the peak load.

The next most popular type of drive for small engines is through a belt. This is not as elastic as electric drive; but where the power can be transmitted by one belt this arrangement is efficient. Where, however, it is necessary to belt to a jackshaft and from this jackshaft to belt to a second shaft and thence to the machine to be driven, the use of generators and motors will be appreciably more efficient. For example: the loss in one belt is usually computed as 5 per cent., and this means that at the first jackshaft 95 per cent. of the original power is available. At the second jackshaft, 95 per cent. of that 95 per cent.—that is, 90 per cent. of the original power—is effective; and at the ultimate machine, all that is delivered is 86 per cent. of the original power. Where short-belt drive is used with some efficient form of idler the losses are much lower—not running more than 3 to 3½ per cent. for one belt.

Direct connection is the preferable method of drive. It is not used so often as the other methods mentioned because the prime mover and the machine driven must operate at the same speed. There are exceptions to this rule; but it may be broadly stated that direct connection is not successful unless the driving and the driven parts of the combination are the products of a single manufacturer. Direct connection is 100 per cent. efficient in the transmission of power.

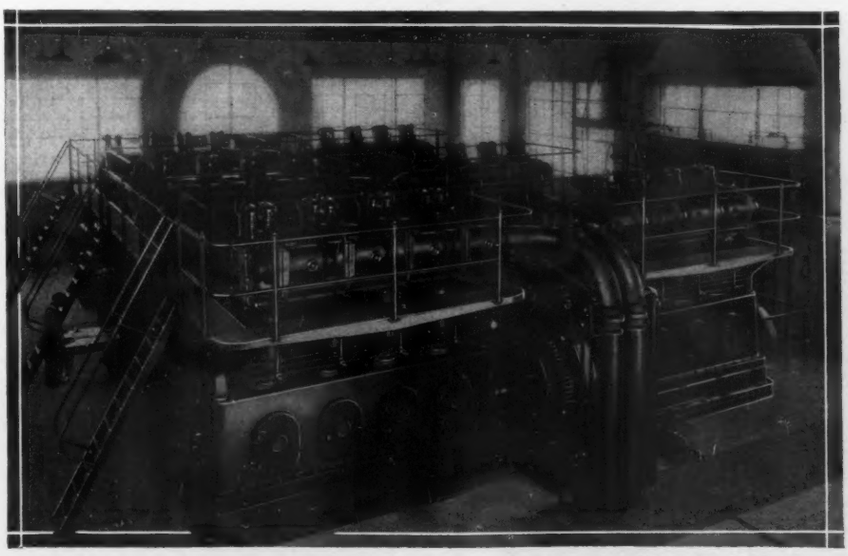
As the primary purpose of this exposition of the heavy-oil engine was to stress its merits for service in ice-making or refrigerating plants, it might be well to amplify these advantages in concluding this paper. The oil engine is admirably suited for service in any manufacturing establishment where power is one of the main items of operating cost and where raw material is a minor one. A refrigerating plant belongs to this class. In an ice-making plant, water in a frozen state is sold to the trade; in a cold-storage plant, the commodity is refrigerated space. Therefore, the principal costs are: labor, power, and fixed charges.

In a refrigerating plant, the load may be divided in this manner: 75 per cent. for compressor drive and 25 per cent. for auxiliaries. Accordingly, the logical type of drive should be one or more direct-connected oil-engine ammonia compressors and one or more oil engines driving a generator set or sets furnishing electric power for auxiliaries or for belt driving these auxiliaries. An installation of this kind is highly desirable because it entails a minimum loss of power.

Oil engines lend themselves admirably to the fluctuations of seasonal demands, such as occur in the manufacture of ice. With an installation consisting of two or more units, the owner can operate at a reduced load factor without sacrificing efficiency. Furthermore, the division into several units makes it possible to shut down a machine for inspection or adjustment without seriously interfering with output.

In an exisiting steam plant, where it would be expensive to keep the equipment running for a light winter load, an oil-engine unit can be employed and will perform a much needed service.

Abstract of a paper read before the New York Chapter of the American Society of Refrigerating Engineers.



Three-unit, 2,400-H.P. oil-engine power plant in a Nevada plaster mill. These engines are of the well-known Ingersoll-Rand solid-injection type.

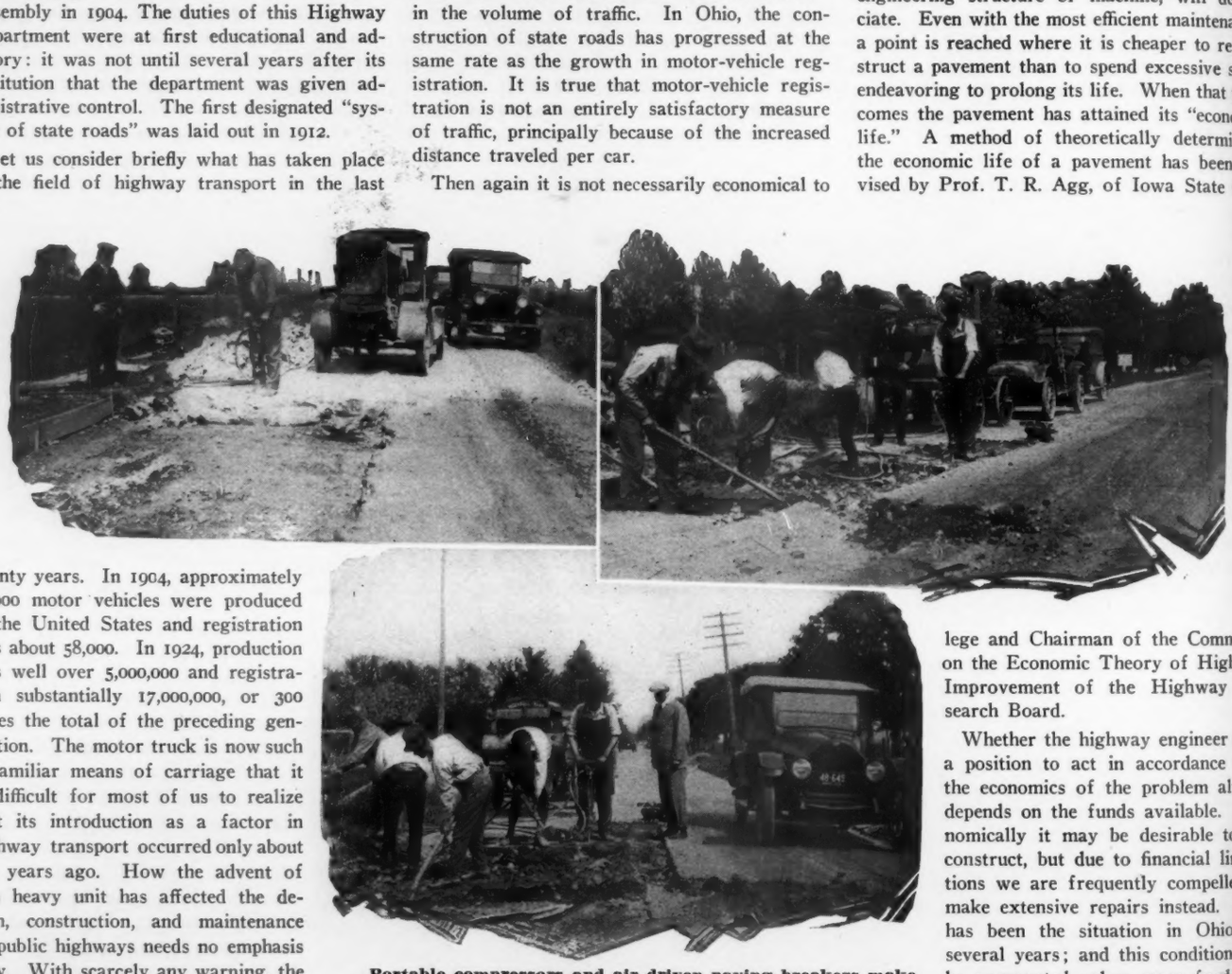
The Mellon Institute of Industrial Research at Pittsburgh, Pa., has announced the production of artificial snowstorms for extinguishing fires. Liquified carbon dioxide is passed from cylinder pressure to atmospheric pressure, and is thus converted into snow at a temperature of 110 degrees below zero. This use of carbon dioxide has been found to be very effective when discharged into confined spaces—active flames being at once "chilled out of existence." Property adjacent to the fire is not damaged in any way by the snow.

Road Failures: Causes and Remedies

By G. F. SCHLESINGER*

HISTORICALLY speaking, Ohio has just completed a double decade of experience in state road matters—a separate department of state government with jurisdiction over state roads having been created by the Ohio General Assembly in 1904. The duties of this Highway Department were at first educational and advisory: it was not until several years after its institution that the department was given administrative control. The first designated "system of state roads" was laid out in 1912.

Let us consider briefly what has taken place in the field of highway transport in the last twenty years. In 1904, approximately 22,000 motor vehicles were produced in the United States and registration was about 58,000. In 1924, production was well over 5,000,000 and registration substantially 17,000,000, or 300 times the total of the preceding generation. The motor truck is now such a familiar means of carriage that it is difficult for most of us to realize that its introduction as a factor in highway transport occurred only about ten years ago. How the advent of this heavy unit has affected the design, construction, and maintenance of public highways needs no emphasis now. With scarcely any warning, the highway engineer became a helpless witness to the excessive overloading of roads he had designed too light for the type of traffic thrust upon them.



Portable compressors and air-driven paving breakers make comparatively short work of removing defective parts of a concrete-surfaced highway preparatory to resurfacing.

Although the subject of this article is *Road Failures,* it is believed that the use of the word failure is somewhat unfortunate in that it implies incompetence, negligence, or culpability on the part of the highway engineer and the highway engineering profession. A so-called road failure is not necessarily nor usually the fault of the engineer.

In the first place, the introduction and extensive use of the motor truck with its heavy concentrated loads could not have been foreseen by the designing engineer any more than it was by the producer and the user of the automobile. And it is a recognized fact that our troubles in the way of road failures have come about largely by reason of the change in the character of the traffic rather than the increase in the volume of traffic. In Ohio, the construction of state roads has progressed at the same rate as the growth in motor-vehicle registration. It is true that motor-vehicle registration is not an entirely satisfactory measure of traffic, principally because of the increased distance traveled per car.

Then again it is not necessarily economical to make road pavements so heavy that there is no chance of failure. We often hear the Appian Way spoken of in this connection—but generally by people who have never seen it. In the days of Imperial Rome, mankind consented to the cruel employment of enslaved captives of war in the construction of roads the foundations of which were composed of blocks of stone five feet in depth. Modern civilization would not countenance such practices; and the taxpayer would stand aghast at the enormous cost of such a design. The Appian Way, in all its history, has never had to withstand the destructive effect of the traffic borne by the average main road in Ohio. Italy, in 1923, had 75,000 automobiles—or 1 to every 490 inhabitants. In the City of Cleveland alone, in the same year, there were 2¼ times that many motor cars.

It is to be expected that roads, like any other engineering structure or machine, will depreciate. Even with the most efficient maintenance, a point is reached where it is cheaper to reconstruct a pavement than to spend excessive sums endeavoring to prolong its life. When that time comes the pavement has attained its "economic life." A method of theoretically determining the economic life of a pavement has been devised by Prof. T. R. Agg, of Iowa State College and Chairman of the Committee on the Economic Theory of Highway Improvement of the Highway Research Board.

Whether the highway engineer is in a position to act in accordance with the economics of the problem always depends on the funds available. Economically it may be desirable to reconstruct, but due to financial limitations we are frequently compelled to make extensive repairs instead. Such has been the situation in Ohio for several years; and this condition will be aggravated unless more funds for maintenance and reconstruction are made available.

The principle of "stage" or progressive construction of roads is based on the assumption that the original pavement is inadequate for future traffic. The engineer plans to use the existing road metal as a foundation for a heavier type of construction when funds become available and traffic increases. It is considered more economical to connect centers of traffic flow at once, and then later to build vertically rather than horizontally in order to meet the requirements of increased traffic and economical maintenance. In the traffic-bound type of gravel-and-stone surfacing, failures of the surface necessitate continual renewals. As is well known, lack of attention to this type of road surface for only a day or two will result

*Ohio State Highway Engineer.

in dismal failures. In many cases, the use of the stage-construction principle and the building of traffic-bound surfaces would not have been resorted to by the engineer had funds been available to connect centers of communication with higher types of pavement.

However, in connection with the subject of road failures, the engineering profession cannot be considered entirely faultless. It must be admitted that, until recent years, the knowledge of the art of road design and construction lagged behind the increase in the volume of road mileage being built and maintained. The importance of highway research was not realized for many years. This may be due to the fact that highway engineers were too busy in a frantic effort to keep pace with the remarkable development that was taking place in motorized traffic. Owing to investigational projects—such as the Bates Road in Illinois, the Arlington Farm experiments of the Bureau of Public Roads, and many other research enterprises under the auspices of state highway departments, road material associations, and other agencies—the progress made in recent years has resulted in more rational and more economical design methods. To verify this fact one need only mention recent changes in practices—such as the use of the thickened edge and the center longitudinal joint in concrete pavements; the importance of a dry consistency; curing methods; accurate measurements of aggregates; the adoption of a soft filler for brick pavements; the development of proper control and of tests for asphalt mixtures; the use of stone of correct sizes and quality for macadam construction; the devising of a practical method of bituminous-surface treatment of traffic-bound gravel-and-stone roads, etc., etc.

Using a Calyx drill for cutting cylindrical sections out of a roadway for test purposes.

As to the remedies for road failures, it is believed that engineers in the past have not been as much concerned about preventive measures as they have been with those of a remedial character. One of the commonest faults of highway engineers is insufficient investigation and examination of the proposed road site before preparing construction plans. A road survey should include not only a determination of the best grades and alignment but also an investigation of such matters as geological formations and character of the subsoil as well as of the existing road metal. In most cases it is illogical to use the same design on all portions of a project. Yet this is the usual practice.

The highway expert, a few years back, always devoted a large part of his attention to the subject of drainage as being the *ne plus ultra* of good road design. While no engineer would, today, dispute the desirability of proper drainage, still he knows that under some conditions ordinary methods are of no avail. Certain dense impervious clays cannot be drained even if tiling is used herringbone fashion, twelve inches on centers, and the side ditches are three feet deep. You cannot drain a sponge dry by inserting a straw in it. The proper treatment of the subgrade where capillary water is present is one of the problems to be solved. Engineers are agreed that the design of the subgrade, as a preventive against failure, is as worthy of their best thought and consideration as is the pavement, itself. The Ohio Division of Highways, in coöperation with the United States Bureau of Public Roads and the Experimental Station of the Ohio State University, is now engaged in an investigation of the subgrade soil of the state. The work is under the direction of Prof. F. H. Eno; and the aim is to obtain the following results:

To establish proper laboratory methods for the analysis of soils for road subgrade control.

To determine the line of demarcation be-

Ingersoll-Rand concrete surfacer removing high spots from a roadway.

tween good and bad subgrade soils—that is, soil classification.

To ascertain, if possible, the best corrective treatment for bad soils.

On a concrete-road project in Washington County various types of porous insulating courses have been constructed beneath the pavement. Continual tests, analyses, and observations as to their effect on the durability of the pavement will be conducted. The same investigations will be made with the non-rigid type of construction. About 70 separate stations, at various points along the state system, will also be established for the purpose of obtaining data to determine a standard method of making subsoil tests.

A certain class of road failures is due to special causes, such as unusual rain storms, extensive land slides, effects of temperature, and traffic concentration on account of deep snow—all of which are beyond the control of the enginer, or they are of such infrequent occurrence that it is not considered economical to provide against them in designing roads. The remedies for failures can be classified in two groups:

First, the replacement of broken up sections of pavement with as little interference with traffic as possible. The latest development in this class of repair work is the use of concrete instead of bituminous mixtures to patch concrete pavements and bases. In this connection there is a large field for the employment of quick-setting, early-strength cements, such as the aluminate compounds. Also, we have found the use of pneumatic tools of great value in repairing concrete because of the increased speed of operation thus made possible, the mobility of the equipment, and the saving in labor costs. In repairing roads, the highway engineer is justified in sparing no efforts to minimize the time traffic is delayed by depriving it of the use of a portion of the traveled surface. A considerable part of the additional expense thus incurred can be offset by cutting down the time lost through one cause or another and by reducing the hazard to traffic.

Second, the resurfacing of sections that cannot be repaired economically. In this class of work full advantage should be taken of any existing salvage value of the old pavement. It is also an opportune time to widen the pavement, should it be considered desirable. When at all feasible—and it usually is—the reconstruction of a worn-out road should go on without detouring traffic. Every project of this kind should be thoroughly investigated by the engineer with a view to determining the additional expense that is justifiable to obviate the detour nuisance.

It should be noted that most of this discussion has been with reference to the road surface. On an average, about 40 per cent. of a road project consists of items—such as roadbed and drainage structures—that do not fail or depreciate except to a relatively small extent, and then on rare occasions. In regard to pavement failures, it is my opinion that they will not be as frequent nor as extensive in the future. This statement is based on the following facts:

There will not be any great or sudden increase hereafter in the concentrated weights of motor units. Weight restrictions are in the statutes of all states.

Rational design methods and improved construction practices have been developed as a result of past experience and highway research.

The maintenance of roads is more adequately organized; and in future all roads will receive closer attention. For example, snow removal is a part of the maintenance operation of every modern highway department.

A knowledge of the traffic, existing and projected, will be very valuable in future road construction and maintenance. The Ohio Division of Highways, in coöperation with the Bureau of Public Roads, is now engaged in a comprehensive transport survey of the state, for use in connection with all future plans.

In conclusion, it is the duty of engineers to keep abreast of the latest developments in highway knowledge; to improve designs and construction methods; and to properly supervise the work of the contractor so that succeeding engineers in this field will have no complaint to make in regard to road failures.

A DOG-POWER RAILROAD

BEGINNING in 1900, a narrow-gage railroad was built northward from Nome, Alaska, until, in 1906, it extended a distance of 80 miles. It was laid with 20-pound rails; little or no grading was done; proper ballasting was impossible; and the locomotives had to be coupled by universal-joint contrivances. By 1911 the most productive gold deposits of the region had been worked out, and the steam service was discontinued.

Then some mushers conceived the idea of rigging up light flange-wheeled cars for their dogs and, so equipped, have been using the road regularly. With half a dozen dogs two men can make from 40 to 50 miles a day with considerable loads of freight. Two years ago the line and the right of way were bought by the territorial government and are being put into better condition for permanent service with a good footing for the dogs.

It will probably surprise many of us to learn that there are in the United States 3,208 air ports and landing fields for the exclusive use of our various airplane services. Of these, 110 are army and navy fields; 46 are air-mail landing stations; 226 are under municipal control; 208 are commercial stations; and 2,618 are potential fields—that is, they are not yet equipped but available for future use as our airplane services expand.

A battery of 24 giant searchlights, with a total candle power of 1,320,000,000, is to be permanently installed for the spectacular illumination of Niagara Falls from the Canadian side. The battery will cost about $60,000 to build and to install; and it is expected that the Ontario Power Commission will donate the necessary power. The lights are to be in use four hours each night; and gorgeous color effects are to be provided for special occasions.

DYNAMITE AS AN EFFECTIVE FIRE EXTINGUISHER

By WARREN T. GREENE

THE extinguishing of the raging flame of a burning gas well by exploding right in it a heavy charge of dynamite once seemed an absurd thing; and the first trial of it was a daring and an apparently hopeless experiment. But the operation has since been done so frequently and so successfully that explanations might be welcomed.

The terrific force and its sudden release are, of course, first thought of and made the most of. It is reasoned that when such a powerful explosive is set off it must have its own way—dispersing whatever surrounds it. If confined in a drill hole in the face of a quarry it disrupts and scatters the surrounding rock. When it is fired in the flaming torch of a gas well the action is precisely the same—it must have its own way. The immense and suddenly released volume of gas, into which the dynamite is transformed, spreads both downward and upward—snuffing out the flame and blowing the blazing gas so high that all connection is destroyed and the flame cannot renew itself.

This explanation is not complete or satisfactory, and fails to recognize the most essential operative condition involved. It is to be remembered that the explosion of the dynamite is as strictly and completely an act of combustion as if considerable time were consumed in the operation. The gases generated are entirely the products of combustion, with their inseparable characteristics; and, therefore, they are not only no longer combustible in themselves but effectively inimical to whatever combustion may be in progress within their reach. The gases constitute an ideal fire extinguisher when properly localized for effective work. They spread out laterally, not only stopping the inrush of the flame-supporting air but putting their fire-extinguishing mixture in its place. They also spread downward and upward—completely severing and separating the rising flaming column from the well, and smother and kill it as far as their contact and admixture extends. They entirely dominate and occupy the immediate premises; and the suddenness with which the gases of explosion take possession is undoubtedly an essential element of their efficiency.

When the smothering and flame-destroying properties of all the exploded gases are recognized and appreciated we may see them employed for fire-extinguishing purposes much more extensively, and, perhaps, often far away from gas fields.

The gas companies of the United States, represented by the American Gas Association, produced in 1924 a total of 405,000,000,000 cubic feet of manufactured gas—serving a population of 52,000,000. This volume of gas would fill a globe nearly 1¾ miles in diameter. During the past year the companies added 440,000 new names to their lists of customers, thus bringing them considerably over the 10,000,000 mark. In the last decade the industrial use of gas jumped 1,000 per cent., the gain being in heating and cooking rather than in lighting.

Tacoma's Second Municipal Hydro-Electric Scheme

Lake Cushman Project is Being Pushed Along Rapidly to Supply Much Needed Current to this Enterprising Washington City

By ROBERT G. SKERRETT

TACOMA, WASH., has been described by an enthusiast as "a city of solidity, saneness, and substantiality—and a market of parts." Reduced to simpler and more specific terms, these alliterations mean that Tacoma has a public-spirited population of approximately 110,000; that its citizenry are wisely bent upon making the most of their opportunities; that the business and industrial life of the community involves activities having an annual value of more than $100,000,000; and that the city is the focal point of trade for a territory extending westward to the Pacific Ocean, eastward to the Cascade Mountains, southward to the state boundary, and northward as far as the merchants of Tacoma can successfully compete with the merchants of Seattle.

Because Tacoma must fight to maintain her dominance in the region mentioned, excellent roads and improved interurban transportation facilities have been provided to render it easy for out-of-town dwellers to reach the city. Within the municipal limits, embracing an area of 43.4 square miles, there are established 375 manufacturing plants. The residential section of the town is made up of 25,000 houses, and 54 per cent. of these are owned by their occupants. Tacoma boasts a number of physical advantages, and among these are a fine, temperate climate and a setting of exceptional scenic charm.

Prior to 1893, the light and water systems of Tacoma were owned and operated by a public-service corporation; but in April of that year the voters authorized the purchase of these systems at a cost of $1,750,000. Immediately

Fig. 1—How the excavation for the power-house foundation appeared in September, 1924.
Fig. 2—The dam site with cofferdam rising above the surface of the water.
Fig. 3—The dump and the entrance to the diversion tunnel. The rock penetrated is of notable homogeneity.
Fig. 4—Artist's conception of how the project will look when completed.

Heading in the diversion tunnel where the overbreak was notably small.

afterwards, the municipality improved the electric lighting plant and increased its capacity by adding new dynamos. These betterments were not of sufficient capacity, however, to take care of the rapidly growing demand. Finally, in January of 1909, the people voted to build at La Grande what is known as the Nisqually hydro-electric plant. This plant is equipped with four turbo-generators, each of which has an output of 5,000 Kv-a. The Nisqually River is fed by waters flowing from the melting bodies of five great glaciers resting in valleys on the slopes of Mt. Rainier; and the construction of the station at La Grande and the associate dam, reservoir, 10,000 foot tunnel, penstock, etc., involved the mastery of many difficult engineering problems. The power house is located about 32 miles to the south and east of Tacoma, and began to deliver current to the city in August of 1912.

For some years, the Nisqually station was able to meet Tacoma's demands for electric current; and the price of that current was low enough to warrant its use for the heating of buildings. As was to be expected, there came a time when the plant at La Grande could not supply electricity for all the people that desired it. The only solution lay in buying current from other sources or in adding substantially to the city-owned facilities; and, early in 1917, an investigation was made of a number of other points where power could be developed economically. As a result of that investigation the so-called Lake Cushman scheme was chosen for fuller study; and in 1919 a special election authorized a bond issue of $300,000 to purchase the Lake Cushman site. Plans for this undertaking were completed in the latter part of 1923, and work was started thereafter as soon as the season permitted.

Hydro-electric Power Unit No. 2 of the City of Tacoma—known as the Cushman Power Project—consists of an initial development of 50,000 H. P. just below a concrete storage dam erected across the valley of the Skokomish River at a point about 44 miles northwest of Tacoma; of a transmission line two score and more miles in length; and of a substation. The total cost of this great improvement is put at $5,250,000. Later on, the intention is to construct another dam at Potlatch, lower down on the Skokomish River, and to transmit the impounded water through a 2-mile tunnel to a power house to be built on Hood Canal. In this power house will be installed two hydro-electric units capable of developing 90,000 H.P.

Looking down into the dam excavation with the river diverted through a temporary wooden flume.

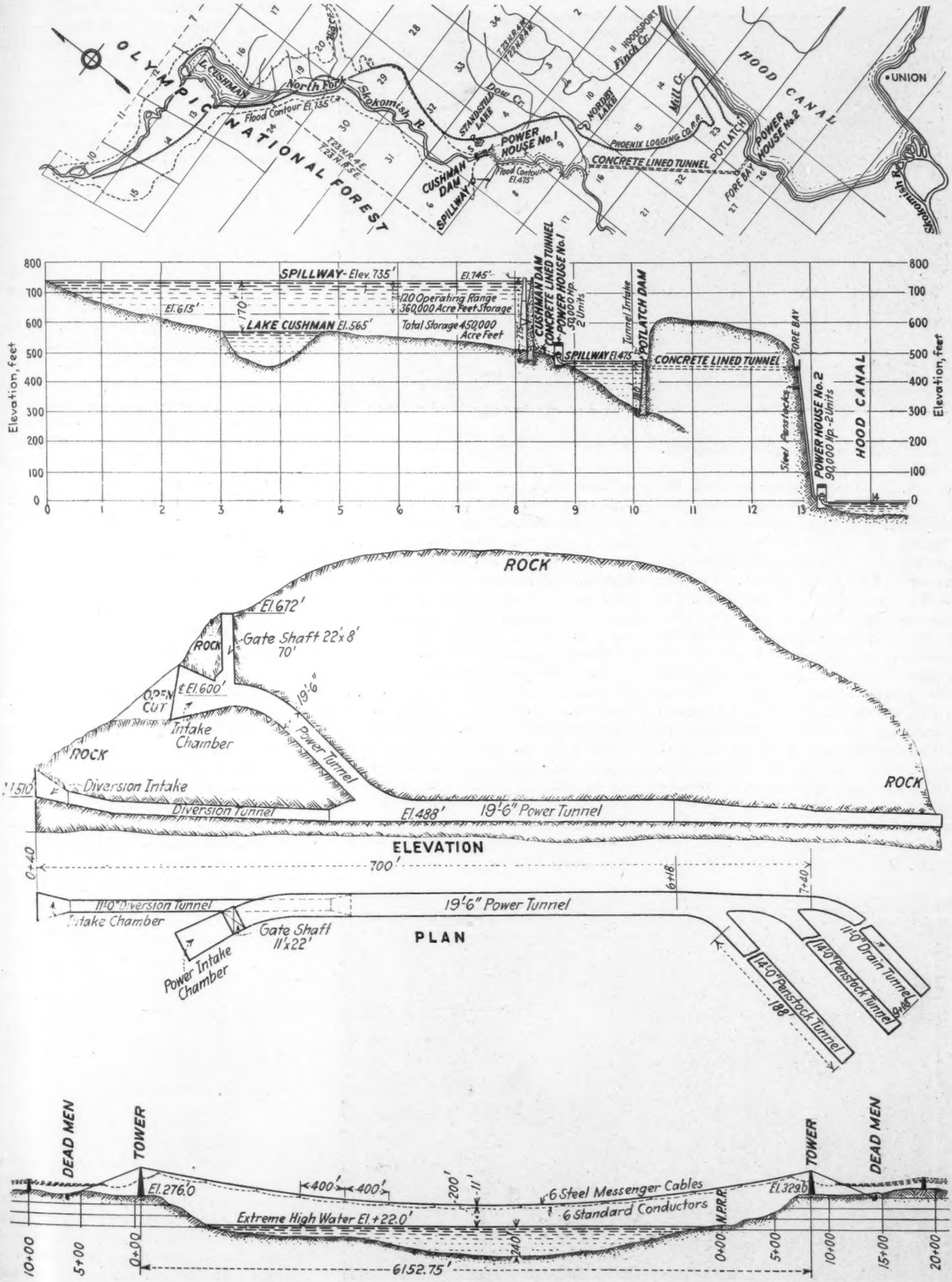
The valley of the Skokomish, in which Lake Cushman lies, has been likened to "a huge bowl carved out of solid rock and plastered throughout with an encrustment of the highest grade of cement." In other words, the geological formation is such as to render this basin water-tight and strong enough to confine the water which will eventually be impounded there. Exploratory core drilling revealed that solid rock underlay the debris forming the river bed at a depth of only 20 to 25 feet; and, therefore, the site chosen for the dam offered an ideal location for the construction of a dam of the constant-angle arch type. The dam, from toe to crest, will be 275 feet in height and wide enough to block the rather narrow rocky gorge through which the river flows. The dam will be formed of 80,000 cubic yards of concrete; and the structure will serve to store 450,000 acre-feet of water—only 365,000 feet of which will be required to effect the complete regulation of the river's flow.

As indicated by one of our illustrations, the plan has required the driving through rock of an 11-foot diversion tunnel and a 19½-foot power tunnel for a linear distance of 700 feet. Associated with these tunnels are two big intake chambers; and rising from the rear of the power-tunnel intake chamber is a rectangular gate shaft 70 feet high and having a cross section of 11x22 feet.

The general contract for the tunnel, dam, and power house was awarded A. Guthrie & Company of Portland, Ore.; and the tunnel work was sublet to P. L. Crooks & Company, Inc., also of Portland. The rock through which the tunnels penetrate is of andesite formation—that is, it is of volcanic origin and similar in structure to the rock forming the backbone of the Andes Mountains in South America. The rock is comparatively easy to drill; but, being what is technically known as "lifeless," it requires more powder to break it than is the case with the average hard rock.

In driving the main power tunnel the contractor has been able to advance at a rate of about nine feet a day; and he has done his drilling with Ingersoll-Rand "Jackhamers" and "Leyner" drifters—keeping his steels in condition with a No. 3 "Leyner" sharpener. The DCRW-23 "Jackhamers" are wet "Jackhamers," and their performance has been notably fine. Operating air for the drills and for the sharpener has been provided by three 9x8-inch Type Twenty portable compressors housed in a quickly built frame structure.

At its discharge end the power tunnel branches into three tunnels—one an 11-foot drain tunnel and the two others 14-foot penstock tunnels. Each penstock tunnel will deliver water to a 25,000-H.P. turbo-generator. The rotating element of each turbine will weigh more than 100 tons, and this huge mass of metal will revolve at the rate of 200 revolutions a minute. The maximum operating head will



Outstanding features of the Cushman Lake Project showing map of territory involved; vertical section of dams, reservoirs, and power stations on the Skokomish River; vertical section of tunnels through rock at Cushman dam; and the cableways by which the transmission lines will be suspended above "The Narrows."

The drill steels for the "Jackhamers" and drifters used in driving the tunnels were handled by a "Leyner" sharpener.

be 260 feet. It is said that the reservoir will hold enough water to drive the turbines continuously after a drought covering a period of four months.

According to a yearbook issued by the Light Department of the City of Tacoma: "The head created for power and the storage provided give the dam a potential value, at the current price of power, of at least $6,000,000, whereas the dam itself will cost only about $1,000,000. This great value of the dam is what makes the Cushman Power Project such an ideal one. It is no secret that, due to favorable physical features and accessibility, power can be developed here at a much less cost than at practically any other site in the West; and Tacoma will be able to continue to point the way in the matter of lowest power rates."

The transmission lines from the Cushman plant will pass the site where the second phase of the project will be developed near Potlatch on Hood Canal—five miles farther down on the Skokomish River. The lines will then run across the Skokomish River flats at the south end of Hood Canal, and thence through Allyn and Purdy to the substation in Tacoma. To reach Tacoma, however, the lines will cross "The Narrows" at a height providing sufficient headroom for shipping. The general scheme by which this will be accomplished is indicated by an accompanying line drawing.

There will be four tall structural steel towers, two on each side of the waterway; and from these towers will be suspended six 1¼-inch steel messenger cables, each of which will have a span 6,153 feet long between its sustaining towers. With a maximum sag of 368 feet the pendant conductors will clear the tideway by 200 feet. From each of these messenger cables will hang one of the transmission lines; and the system calls for the longest span yet designed for a similar purpose in the United States.

Three 9x8-inch Type Twenty portable compressors furnished air for driving the tunnels for the Cushman Lake project.

The messenger cables will be strong enough to carry their normal load when covered with a sheath of ice half an inch thick and when exposed to a gale blowing at the rate of 72 miles an hour—representing more rigorous weather conditions than have yet been recorded in that part of the country. The towers on the east shore will be 272 feet high and those on the west shore 325 feet high. To obviate the chance of total disablement of the distributing system, the six cables are divided into two separate circuits; and the distance between the circuits will be ample enough to allow one circuit to be cut out of service and to make repairs without unnecessarily endangering life or the cables of the neighboring circuit. Each circuit will be capable of carrying indefinitely the full load transmitted from the generators; but the performance will not be as economical as when all the transmission lines are in use.

According to an official statement made by the municipal authorities, the demand for electric power in Tacoma has reached such proportions and is increasing so rapidly that Hydro-electric Power Unit No. 2 will be able to take care of the augmented load for a period of only five years after that plant's completion. This means that work on the Potlatch station will have to be taken in hand before the expiration of five years.

WORLD'S MOST SPECTACULAR ELEVATED RAILROAD

THE highest elevated railroad is in Peru, and extends for a distance of 140 miles from Callao to Oroya, on the eastern slope of the Andes. In about 100 miles it rises from sea level to 15,665 feet, just a few hundred feet lower than Mt. Blanc, in Switzerland. The building of the line, begun in 1870, was one of the greatest engineering tasks the world has ever known. While the actual distance between the terminals is only 80 miles, unavoidable turnings and zig-zags called for a road nearly double that length.

In places the line runs in galleries which were cut in the faces of precipices by men lowered in boatswains' chairs. The railroad emerges from tunnels right onto bridges, sustained by piers more than 200 feet high, and then disappears again in other tunnels. It is the only line in the world down which a train may run 100 miles without the help of a locomotive. The greatest danger that faced the workmen on the job was a local fever; and it is said that in one cut alone as many as 700 died of the malady.

Sodium-sulphate deposits in the Province of Saskatchewan, Canada, have recently been investigated by the Industrial Waste Products Corporation, of New York, with a view to exploiting them. The plan is to produce the chemical by a new spray-drying process. This process, it is reported, was tried out in a salt works near Dunkirk, and resulted not only in increasing the output from 30 to 50 tons daily but in reducing the annual expenditure by about $50,000.

Canada Rich in Deposits of Feldspar

By SIR STOPFORD BRUNTON

CANADA possesses well-nigh unlimited feldspar resources—pegmatite dykes being found over an immense area extending from Labrador, in the east, through the provinces of Quebec, Ontario, northeastern Manitoba, and thence into the northwest territories. Virtually the whole of the Provinces of Quebec and of Ontario consist of crystalline rocks in which feldspar dykes and stringers are of frequent occurrence; and, while by far the larger number of these bodies is too small to be of economic importance, there are various localities in which feldspar quarries have been developed successfully.

Feldspar is a kind of crystalline mineral, easily cleavable and non-lustrous, having a complicated and variable composition containing potassium, sodium, calcium, alumina, and silica. This non-metallic mineral is divided into three classes: potash feldspar, soda feldspar, and lime feldspar. The potash spar is pinkish in color and breaks with cleavages at right angles, while the lime and the soda spars range from white to gray and cleave at an acute angle. Potash spar is the most valuable from the commercial standpoint; and it is this variety that forms one of the constituent minerals of the granites that are so abundant throughout the Dominion.

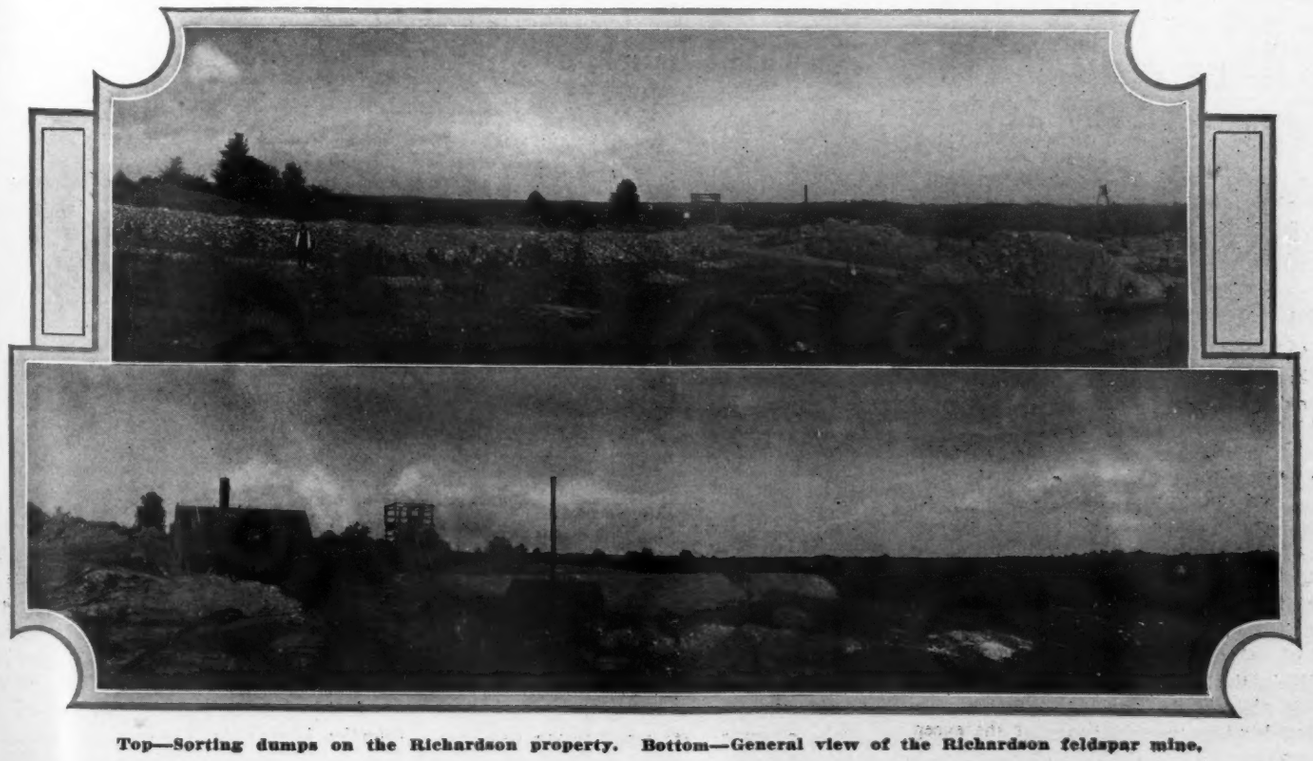
Most of the productive feldspar areas in Canada are located in the Eastern provinces. In Quebec, on the north shore of the Gulf of St. Lawrence, a quarry has been opened from which some shipments have been made; in the township of Derry, near Buckingham, there is a large deposit of potash spar; and on the Lievre River, in this same region, soda spar of good quality has been mined and shipped. In Ontario, quarrying for feldspar is being carried on at Verona and at Wanipitei. Besides these deposits there are many others that are merely prospects; but the quarries which are now being worked are capable of taking care of the present demand.

The market for feldspar showed some improvement during the first half of 1924. The quantity mined amounted to 20,360 tons, and the sales totaled 18,239 tons valued at $143,146. During the corresponding period of 1923 about 17,622 tons, worth $129,890, were sold. Of the material marketed last year, Quebec and Ontario deposits supplied 10,904 tons and 7,335 tons, respectively. Exports for the first half of 1924 also showed considerable advance over those made during the same period in 1923—that is, 18,313 tons as compared with 11,351 tons. It is interesting to note here that most of the 1924 output was shipped to the United States—less than 1 per cent. of the crude being ground in the local mills at Kingston and Toronto .

Two grades of potash spar are permissible in the trade: No. 1 spar should be free from minerals which may impair its purity; it should have a potash content of at least 12 per cent.; and it may contain not more than 10 per cent. of quartz. A small percentage of quartz is not deleterious so long as the amount is constant. The requirements for No. 2 spar are not so rigorous and depend upon the use for which the material is intended. Impurities do not matter for such a thing as poultry grit, for example; and the color may even be advantageous in stucco.

The uses of feldspar are many, but the most important is in the manufacture of pottery where it serves to put the glaze on earthenware after the latter has been fired. This glaze is suitable not only for crockery but likewise for tile, stoneware, porcelain, etc. Glazes are transparent so that the colors, painted on the crockery before the glaze is applied, are visible through it, while enamels are opaque and conceal the surface beneath them. In addition to its employment as a glaze, feldspar is utilized in the making of opal glass. A spar high in soda content is satisfactory for this purpose.

Artificial teeth are also made from feldspar, and this same substance is used instead of gold and other metals as a filling for teeth. For dentistry, only the finest white potash spar is selected; and, naturally, the amount required is small. Abrasive soaps contain spar as an ingredient—the spar being ground very fine so that it will scour without scratching. No. 2 spar is used for poultry grit and for roofing; for which latter purpose a colored spar is preferable to a white one. On account of its potash content feldspar is employed for fertilizing,



Top—Sorting dumps on the Richardson property. Bottom—General view of the Richardson feldspar mine.

Richardson feldspar quarry in Bedford Township, Ontario.

but only to a limited extent because the average raw material probably does not contain over 10 per cent. potash. Furthermore, most of the extraction processes, while admittedly favorable on a laboratory scale, are too costly for commercial practice.

AN AMPHIBIAN AIRPLANE

THE most perplexing problem in connection with the airplane is not so much one of actual flight—which may be considered quite satisfactorily solved—as one of alighting. For starting, the location can generally be selected, but the place for landing cannot always be chosen in advance. Sometimes it may be preferable or even imperative to alight on water when only dry land is available.

The ideal airplane should therefore be amphibious; and such a machine has made its appearance. The Loening Amphibian, first seen at Bolling Field, Washington, D. C., on January 18, is of metal construction throughout; has a fuselage shaped like a boat that enables it to alight comfortably on the water; and is also fitted with wheel gearing so that it can run along the ground.

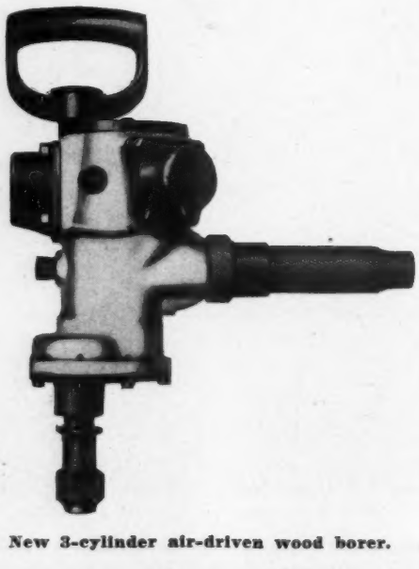
RICH FIND OF SILLIMANITE

ACCORDING to recent press reports, a large deposit of sillimanite has been discovered in India; and it is the first deposit of its kind of sufficient magnitude to be of commercial importance. Sillimanite can be heated to 3,326°F. without softening or cracking, and because of this it is superior to any other known refractory substance. The United States Bureau of Mines has been trying for years to produce by artificial means this fire-resisting mineral, but so far without success. The deposit in question is located about 100 miles west of Calcutta, at the foot of the Himalayas. Curiously, the material has been used there for a long while in the making of pottery. The natives, however, were unaware of the exceptional value of the mineral which they thus employed simply because it was at hand.

NEW PNEUMATIC WOOD BORER

A NEW light-weight, reversible, air-driven wood-boring machine, designated "Size DD," has recently been brought out by the Ingersoll-Rand Company, New York City. This drill is suitable for boring holes up to one inch in diameter in woods of all kinds. In construction, this machine is similar to the three other cylinder drills manufactured by the same company. From the maker's standpoint, these cylinder drills have given such satisfaction in service that it was considered advisable to develop this wood-boring tool.

Briefly, the outstanding features of this type of machine are: A special 3-cylinder motor; a light-weight aluminum case with steel bushings cast in place in all the bearing holes and in the throttle hole; a renewable crank-pin sleeve; and renewable and interchangeable cast-iron cylinders. The feature of cylinder replacement is a valuable one because it renders it possible easily to replace a worn cylinder and thus to make the motor as good as new at a moderate cost. All the rotating parts of the 3-cylinder motor are accurately balanced to prevent vibration and to reduce the wear and tear on the machine.



New 3-cylinder air-driven wood borer.

The principal characteristics of the "DD" drill are:

Average working speed	705 R. P. M.
Weight, including grip handle and chuck	15 lbs.
Length of feed, with feed screw	2½ ins.
Length overall, with grip handle	15 ins.
Distance from side to center of spindle	1 9/16 ins.
Size of hose recommended	½ in.

The drill comes with a spade handle and a bit chuck; but the grip handle may be substituted by a breast plate or by a feed screw and the bit chuck by a drill chuck if it is desired to make the drill suitable for a wider variety of work. Every part of the new cylinder drill is accessible for inspection; the tool is high powered; and the manufacturer claims that its upkeep cost is low and that it is economical in the consumption of air.

AGING QUALITY OF LEATHER

NORMAL aging has but little effect on the strength of leather, according to tests recently completed in the leather laboratory of the United States Bureau of Standards. Twenty samples of new belting leather showed an average tensile strength of 5,045 pounds per square inch, while other samples, that have been allowed to age for ten years, showed an average tensile strength of 4,515 pounds per square inch—a decrease in strength of approximately 15 per cent. during that period.

It is of value to note that no special storage conditions were created—the leather remaining in the laboratory under normal atmospheric conditions and at room temperature. As indicated by these tests, leather may be satisfactorily stored under ordinary conditions of humidity, temperature, ventilation, and light. Extreme dampness and exposure to direct sunlight should, of course, be avoided. This property of leather is advantageous in view of the fact that shoes, baggage, and many other leather articles may be from one to three years old before reaching the consumer and must then give satisfactory service for many more years to come.

The United States burns as many incandescent lamps as the rest of the world combined. The average candle power per lamp has advanced from 16, in 1905, to more than 60 at the present time, while the average watts consumed has remained at about 55, that is, practically stationary. It is estimated that we use 350,000,000 bulbs annually and that the rate of consumption increases 10 per cent. a year.

Quarrying Limestone by Thoroughly Modern Methods

The Virginia Limestone Corporation is a Fine Example of What May be Accomplished in This Way

By RICHARD T. JACKSON

THE Virginia Limestone Corporation, located at Klotz, Va., on the Virginian and the Norfolk & Western Railways, is the largest quarry the writer has ever seen that is operated exclusively with "Jackhamers." During the year 1924, or rather the working season of ten months, quite 500,000 cubic yards of rock was removed from this quarry with a battery of DDR-13 and BCR-430 "Jackhamers"—one of the latter being in permanent use at the crusher for breaking stone too large to enter the jaws. A number of the DDR-13 rock drills have been in service for six years, and are still doing good work.

As the quarry is situated on a hillside and near a river, the overburden is removed by hydraulic stripping, which has proved very satisfactory. Electrically operated pumps first raise the necessary water to a 40,000-gallon tank, located at an elevation of 250 feet, whence it is pumped by means of a reciprocating unit to the point of operations. A Jumbo type of nozzle, made especially for the purpose by the LaFrance Fire Engine Company, delivers the water at a pressure of 140 pounds. This method of stripping has been found to be inexpensive, despite the fact that a very hard overburden, consisting of boulders and red clay, has at times been encountered. The washed material is carried down the hillside to the foot of the quarry and then conveyed by underground piping to the river.

The rock formation at this site lies in horizontal strata having a thickness varying from 14 to 30 feet. After stripping is completed, drilling is started about 12 feet back from the face and carried to the stratum below. The drill holes are from 3½ to 4½ feet apart—their depth depending on the thickness of the bed of rock. As a matter of fact, with the exception of the 30-foot stratum which is drilled to a depth of 27 feet, the holes are usually carried to the underlying layer of rock. As the strata are well defined—in some cases having a few inches of clay or loam between them, the shots break the rock clean the full depth of 30 feet. The bench is not uniform in length because drilling across the quarry face is carried to a point from which the rock will break to best advantage. For bench drilling, the DDR-13 "Jackhamers" are used exclusively—a 2¾-inch starter, with 3-foot changes of steels each of which has a variation of $^1/_{16}$ inch, being utilized for the 27-foot holes. After shooting the bench, the larger pieces of rock are broken up by blockholing with BCR-430 "Jackhamers."

All the steels in service are kept fit for their work by a No. 4 "Leyner" sharpener—the

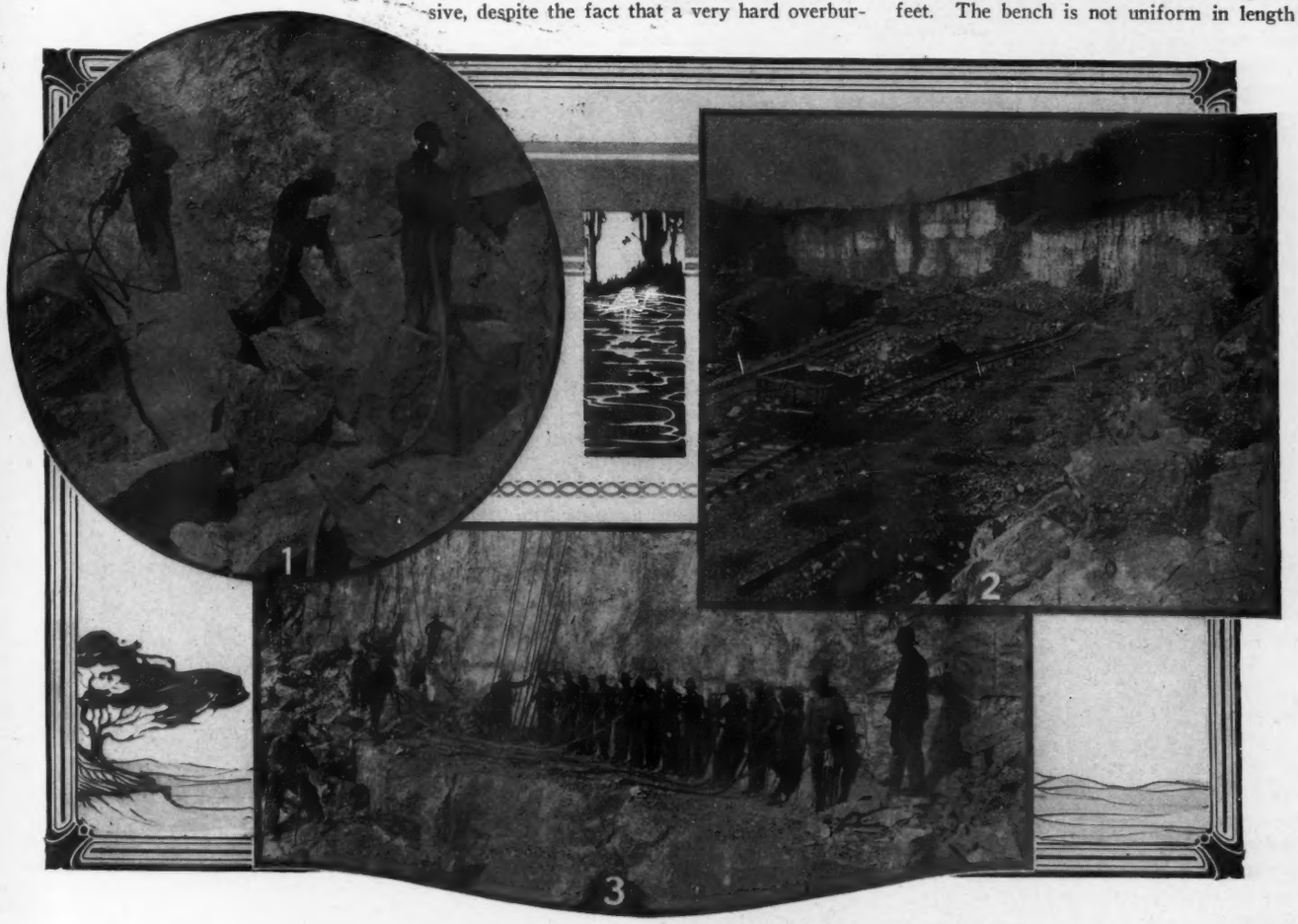
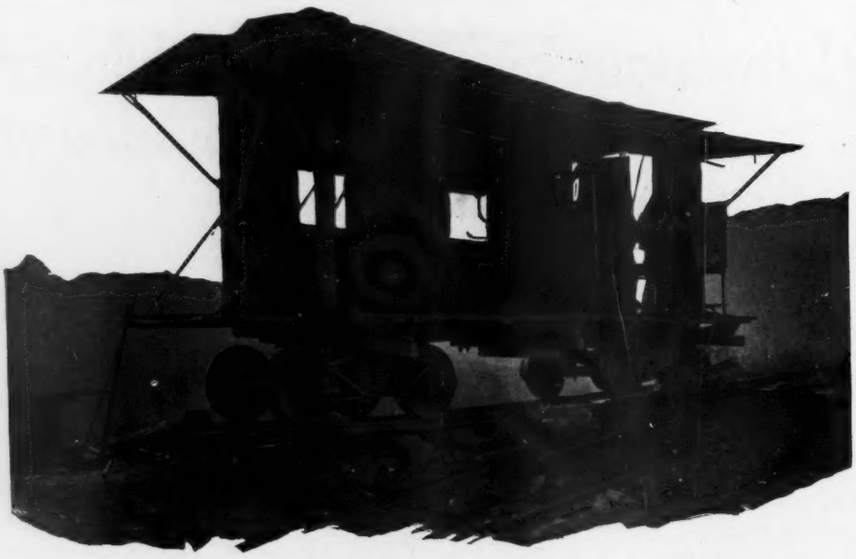


Fig. 1—Using "Jackhamers" to blockhole large pieces of limestone.
Fig. 2—The expansive face of the quarry at Klotz, Va.
Fig. 3—"Jackhamers" drilling 27-foot holes on a bench.

blacksmith shop being mounted on wheels, of the same gage as the railway, so that it can be shifted readily as close to the point of drilling as may be desirable. Operating air for the drills and for the other pneumatic equipment used about the quarry is furnished by an Ingersoll-Rand Class "PRE" compressor. Air is fed to the "Jackhamers" through a 4-inch line carried over the crest of the rock face, which measures 212 feet from top to bottom at its highest point. This main air line is, of course, far enough back from the face to permit quarrying to go on without the need of frequently shifting the piping. Drop lines, 1½ inches in diameter, are connected to the main line. Each drop line leads to a suitable manifold at the point of operations and serves two drills.



Portable blacksmith shop which takes care of all the drill steels used at the quarry.

With the quarrying done, the blasted rock is loaded on 15-ton cars by means of a huge steam shovel which is said to be the largest of its kind similarly employed in the South. Its scoop has a capacity of 3½ cubic yards of stone or of 5 cubic yards of dirt. This shovel is handled by Mr. M. O. VanOrt, who holds the 1924 record for this class of work—having handled 3,840 tons of rock in ten hours and on five separate days. The 15-ton cars are a part of what is known as the Woodford system—an electric third-rail system which enables the operator, located in a tower at the crushing plant, to have perfect control at all times over the movement of the cars. The cars travel to and fro between the shovel and the crusher—the round trip being about a mile.

This third-rail system is electrified in sections—in this particular case ten sections—and the control of the cars is effected either by applying or by shutting off the current, as the case may be. In other words, each car is provided with a selector switch. If the car is at a standstill, the operator applies a current of 250 volts—this being the motive current. The switch selects this current, and the car starts. To stop a car, on the other hand, the 250-volt current is cut off and one of 110 volts applied instead. This operates the brake, thus bringing the car to a halt. In addition to running the cars the operator also dumps them at the crusher. Every car is equipped with two 35-H. P. motors, one on each axle; and, for the sake of interchangeability, the dumper hoist has been provided with the same kind of motor.

Reaching the crusher, the rock is dumped onto a 60-inch by 16-foot apron feeder. This is a heavy, steel conveyer which delivers the rock to a 40x60-inch jaw crusher. Should a large piece of rock become lodged in any way either in the feeder or the crusher it is freed by means of an "Imperial" air hoist fitted with a large hook. This hoist is also useful for lifting parts in repairing the apron feeder or the crusher, and is so arranged that it can transport repair and spare parts from the 15-ton quarry cars to a central position in the crusher plant—an overhead trolley making this possible. This hoist has been in service since the installation of the plant, seven years ago; and, despite the fact that it has been working under severe operating conditions, it has had but one breakdown which, it is believed, was caused by jamming the hoist and stripping gears.

It is an awe-inspiring sight to see huge pieces of rock moving up the conveyer and toppling over into the crusher to be chewed up with as much ease as if they were chalk. It is not at all unusual for stones weighing from five to ten and more tons to go through—in fact, according to Mr. G. W. Lenzie, vice-president of the Virginia Limestone Corporation: "I have known this crusher to handle a stone weighing quite twenty tons. This is, of course, a rare occurrence and, in the case in question, was made possible only by the shape of the rock which enabled the air hoist and the apron feeder to properly upend the mass and to place it in the crusher."

Another very necessary piece of machinery at this crusher is the BCR-430 "Jackhamer" previously referred to. In the event a stone is too large, or if it does not fit into the crusher jaws by reason of its shape, it is drilled and shot on the spot to save time. This operation takes but a few minutes, as the drill is permanently attached to the air line. While this procedure does not often have to be resorted to, nevertheless the drill soon pays for itself because it does not take much of a tie-up at this stage to result in far heavier outlays than the cost of such a tool.

Mill, quarry, and part of the camp on the property of the Virginia Limestone Corporation.

After the rock has gone through the crusher it is fed onto a gravity screen of 4½-inch mesh. The material that passes through this screen is conveyed to what is known as Plant No. 3, which is equipped with a 48-inch by 24-foot revolving screen. At this point, all the over-size stone is carried to a bin—Bin B, while the stone that falls through a 2½-inch ring is transported to the washing plant

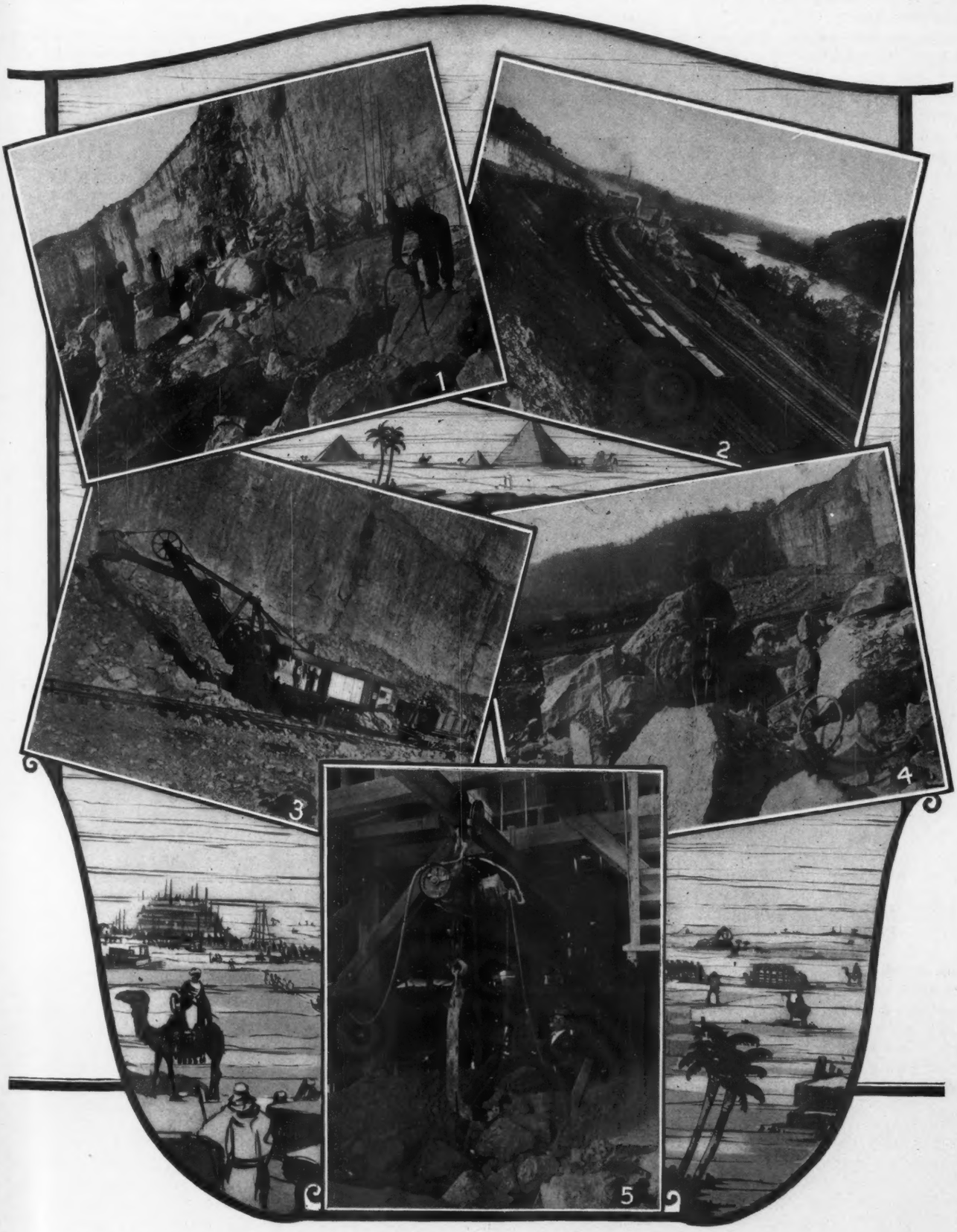


Fig. 1—Large pieces of rock are drilled and broken up by small charges.
Fig. 2—General view of the railway yard and crushing plant of the Virginia Limestone Corporation of Klotz, Va.
Fig. 3—The 120-ton steam shovel which loads the quarry cars with rock.
Fig. 4—Close-up of a workman drilling block holes with a "Jackhamer."
Fig. 5—Loosening bridged or jammed stone in a crusher chute by means of an Ingersoll-Rand air hoist.

where it is cleaned and separated into four different sizes, namely:

Limestone sand, material that will pass through a ⅜-inch ring.

No. 1 Stone, material that will pass through a ½-inch ring but will be held by a screen of ⅜-inch mesh.

No. 2 Stone, material that will pass through a 1⅛-inch ring, but will be held by a screen of ½-inch mesh.

No. 3 Stone, material that will pass through a 2½-inch ring but will be held by a screen of 1⅛-inch mesh.

Over-size stone, that is, any that will not pass through the 4½-inch-mesh gravity screen, goes to a pair of No. 7½ gyratory crushers, whence it is carried to the highest point in the plant and delivered onto a pair of 48-inch by 24-foot revolving screens. The crushed rock is now ready for grading, as just described. Any rejections at this stage of the operations are taken to Bin B. This material is fed into two No. 6 and two No. 4 gyratory crushers; next, it is again conveyed to the top of the plant; and then it is dumped into one of the 48-inch by 24-foot revolving screens for grading into five different sizes. Beneath the revolving screens are four vibrating screens, which can be fitted with screen cloth of any suitable size, depending on the grade of rock desired. The finished product is stored in bins, according to size, from where it is either loaded into cars for shipment to the consumer or carried to near-by storage piles.

A total of 100,000 tons of crushed stone can be accommodated in the space set aside for outdoor storage. Here is piled that part of the daily production that is not needed for immediate shipment, or any output in excess of the amount for which railway cars are available. The piling equipment consists of a McMyler crane with a 50-foot boom and a 1½-yard clamshell bucket.

The loaded cars at the company's yard—which has sufficient room to hold 75 empty and 75 loaded cars—are shifted by gravity. To be explicit, the cars descend by gravity onto a 100-ton scale, which weighs them automatically, whence they go in the same fashion to that section of the yard assigned to cars ready for shipment. The marketable product is sent anywhere within a radius of 300 miles; and the rated capacity of the plant is 3,000 tons daily, although 3,800 tons have been crushed in the course of a working day. A 1-day record shipment consisted of 78 cars of 55 tons each, or a total of 4,290 tons of crushed stone.

The company has recently expanded its plant by the installation of a cableway, which makes it possible to carry its product across New River to the Norfolk & Western Railway, 1,000 feet away. This aerial conveyer, which was manufactured by the Interstate Equipment Corporation, of Roanoke, Va., is automatic in its operation; has a capacity of 1,000 tons in a 10-hour day; and is now handling about 7 per cent. of the output of the quarry.

The product of the Virginia Limestone Corporation is thoroughly washed two and even three times before shipment—fresh water being used for each bath. This accounts for its very clean appearance. About 7½ per cent. of the output is a fine dustlike substance, known as ground or agricultural limestone; but the greater percentage of the output is in the shape of crushed stone that is so much in demand for railway ballast, for road construction, for concrete work, etc., etc. Rubble, that was formerly thrown away, now finds a ready market for the building of concrete roads.

Much of the information contained in this article was graciously furnished by Mr. G. W. Lenzie, vice-president of the Virginia Limestone Corporation, and by Mr. W. B. Bobbitt, general manager.

The Interstate Commerce Commission has recently announced that 9 out of the 47 railroads ordered to install automatic train control by January 1, 1925, have fulfilled requirements. The roads now so equipped are: Chicago, Rock Island & Pacific; Chicago & Eastern Illinois; Chesapeake & Ohio; Atchison, Topeka & Santa Fe; Galveston, Harrisburg & San Antonio; Norfolk & Western; Oregon-Washington Railroad & Navigation Company; Reading; and Southern Pacific.

Left—Corner of portable blacksmith shop containing a "Leyner" sharpener and an air-operated forge. Right—Air for driving all pneumatic equipment in the plant of the Virginia Limestone Corporation is furnished by an electrically driven compressor.

AN ISLAND OF IRON

KOOLAN Island, off the northwest coast of Australia, has recently been well named "Island of Iron." An outcrop of iron ore, a hematite, forms the crest of a ridge, along its southern side, rising at one point to a height of 600 feet. At two places where the outcrop was measured it showed a thickness of about 100 feet, apparently all solid ore; and experts estimate that there are 75,000,000 tons above tidewater. A very large portion of the mineral can be mined without the cost of removing the overburden. Analyses of four samples showed 94, 92, 95, and 97 per cent. of ferric oxide, with 0.14, 0.03, 0.03, and 0.02 per cent., respectively, of phosphorus. Of sulphur there was no trace. The island is seven miles long and has a maximum breadth of three miles at its eastern end.

Pneumatic Tools Save Life When Concrete Building Collapses

By THE STAFF

SANTIAGO, Chile, following the long-established custom of some of the older European countries, has for years maintained a *Caja de Crédito Prendario* or Government Pawnshop. With ample reason, the citizenry have pointed with pride to this institution housed in an imposing 4-story concrete building located in the heart of the business section of that enterprising South American city.

Early this year, for reasons not yet disclosed, this apparently sturdy structure suddenly collapsed. People in the neighborhood felt the earth tremble about 2:35 in the afternoon, and this was followed immediately thereafter by a crashing sound and the generation of a dense cloud of dust which completely enveloped the scene of the disaster. When this cloud was dissipated, the Government Pawnshop was found to have tumbled to the ground like a castle of cards—precipitating into the cellar an enormous mass of material and a large share of the commodities stored on its four floors.

The collapse of the building cluttered the cellar with great piles of commodities and shattered masses of concrete and reinforcing steel.

At first, the cloud of dust and the explosion-like noise caused the people in the street to believe that a fire had broken out; and the prompt arrival of the fire-fighting apparatus strengthened this assumption until the true nature of the disaster was made plain. From the well-known Santiago newspaper, *El Mercurio*, we have obtained the following particulars of this grievous happening which entailed the loss of life of twelve or more persons and the injury of ten others.

"Taking proper precautionary measures, the volunteers of the hook-and-ladder company and troops of the Buin Regiment of Infantry began the difficult task of clearing away the ruins sufficiently to make possible the rescue of survivors, buried under the debris, whose cries for succor could be heard. The work from the beginning was very arduous and the utmost care was necessary lest the remaining walls fall in upon the workers.

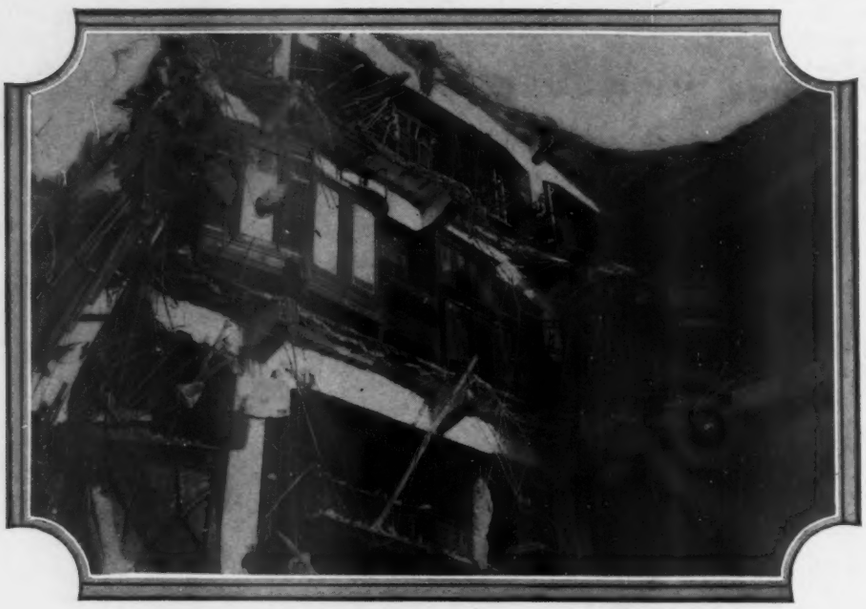
"One of the volunteers of the fire department succeeded in worming his way into the cellar through a small passage opened by his comrades and the troops, and he ascertained that there were in the cellar and still alive, though covered with debris, several of the pawnshop employees. In the same way, water was carried to them and oxygen administered where necessary to revive them.

"According to information furnished by one of the survivors—who was working in the building at the time of its collapse—he and a fellow workmen were cutting out, on the lower floor, a column that was to be replaced by a stronger one. No sooner was the column removed than all the floors above sagged and dropped into the basement.

"The rescue work would have been seriously impeded had it not been for the prompt action of the International Machinery Company. This well-known commercial house quickly dispatched to the scene a portable air compressor and a capable personnel familiar with the operation of the machine and the handling of air-driven paving breakers and clay diggers. These pneumatic tools rapidly broke up the large pieces of reinforced concrete so that the shattered material could be cleared away by the soldiers. With the concrete blocks thus disposed of it was a comparatively easy matter for workmen to cut the tangled reinforcing bars with hacksaws and to make it possible to lift out the persons imprisoned beneath."

It is undoubtedly a fact that the toll of life would have been heavier had it not been for the relief afforded by the 5x5-inch portable compressor and the associate pneumatic tools. We are informed that the operation of the Ingersoll-Rand equipment was directed by Mr. Samuel Jory, the manager of the International

Two views of the interior of the Government Pawnshop shortly after the catastrophe.



Beds, wardrobes, and pianos filled a good deal of space in the Government Pawnshop.

Machinery Company, and carried out by Messrs. J. L. Clarke, José Garreton and A. N. Baudin, all members of that organization. Through their joint efforts eight living persons and eleven dead were removed from the ruins.

NEW PROCESS PRODUCES METHYL ALCOHOL

THE synthetic production of methyl alcohol, at the Leunawerke air-fixation works at Merseburg, is conspicuous among the German chemical achievements of 1924. This process, so it is reported, is based on the catalytic synthesis of carbon monoxide and hydrogen under pressure and at high temperatures. The resultant fluid is fractionally distilled for methyl alcohol.

It has recently been announced that the higher boiling constituent from this reaction is a crude light oil that can be effectively used as an automotive fuel. Its inventors have named it "synthol." It will be interesting to observe what real commercial success, if any, the fuel attains.

STAINLESS SILVER

IT seems somewhat remarkable that silver, which stains readily, has so long retained its status as a precious metal. And now *The Engineer* tells about a new silver alloy that is virtually stainless. It contains 92½ per cent. of silver—the other constituents not being revealed.

So far, only about 600 ounces have been produced, but it has been tried by several manufacturers who report that it is easier to work than standard silver except during buffing and finishing. A test at Sheffield University showed that the new metal was hardly stained when exposed to corrosive gases, and that that slight discoloration could be easily wiped off with a piece of dry leather.

EDUCATING THE TRAVELER

THE backbone of a railroad is its roadbed; and safety of travel and operating efficiency depend in large measure upon the care exercised all along the line in keeping track, ties, ballast, etc., in first-class condition. The public at large little realizes how much work is thus involved to insure comfort and security in transportation.

Here we have an example of how the maintenance of way department of the New York Central Lines meets one phase of these rather complex demands. The pneumatic tie tamper lightens labor, saves money, and does far better work than is practicable in tamping rock ballast by hand methods.

Courtesy, New York Central Lines.

Pneumatic tie tampers in use on the New York Central Lines.

The accompanying photograph illustrates one of a series of folders, entitled *Food for Thought*, issued fortnightly by the New York Central Lines. The purpose of the publications is to familiarize the traveling public with the manifold problems of the modern trunk-line railroad and how they are successfully met by these essential common carriers.

AMERICAN OIL ENGINES FOR EUROPE

A CONNECTION of much significance to the engineering world has lately been arranged between Carels Brothers of Ghent, Belgium, and the Ingersoll-Rand Company of New York City, by which the Belgian concern will have the right to manufacture the well-known Ingersoll-Rand solid-injection type of oil engine.

Carels Brothers—organized in 1875—have long enjoyed a prominent place in the industrial life of Belgium, a country of outstanding importance among the engineering and manufacturing nations of the world. Today, after successive periods of expansion, Carels Brothers are officially known as the Société d'Electricité et de Mécanique.

Carels Brothers were among the first of the European licensees to work under the Diesel patents; and Carels-Diesel engines have won wide recognition in many fields of service because of their excellence. Even so, Carels Brothers have sought to strengthen their enviable position in this department of engineering by means of the working rights obtained from the Ingersoll-Rand Company.

The interesting feature of this arrangement is that Europe has now come to America for the latest and the highest developments in heavy-oil engines. Thus American skill turns the tide of technical obligation by giving the fruits of its labor to Europe—the land in which the heavy-oil engine originated.

ESTHONIA'S OIL-SHALE INDUSTRY

ESTHONIA is rapidly developing an oil-shale industry that promises to supply not only the country's own needs but to yield a surplus for export. Almost the entire 1924 output of oil, representing 25 per cent. of her requirements, was marketed; and its use resulted in a saving of about 5,648,000 poods of coal. (A pood is equivalent to 36.113 pounds.)

The 1925 production of the two oil-distilling plants located at Kuchtel and at Kuckers, which began operating this spring, is estimated at 20,000,000 poods of oil, or a little less than 40 per cent. of the country's requirements. Of this year's output, 4,000,000 poods will be taken by the railways and 15,000,000 poods by industrial establishments.

To facilitate distribution, an oil tank with a capacity of 250,000 poods has been leased by the Esthonia Oil Shale Mines; and from this storage reservoir the fuel is pumped directly into ships and into tanks at the points of consumption.

How Congo Copper is Making History

Katanga, Which Was Once in the Grip of the Slave Trade, is Now an Immense Industrial Area

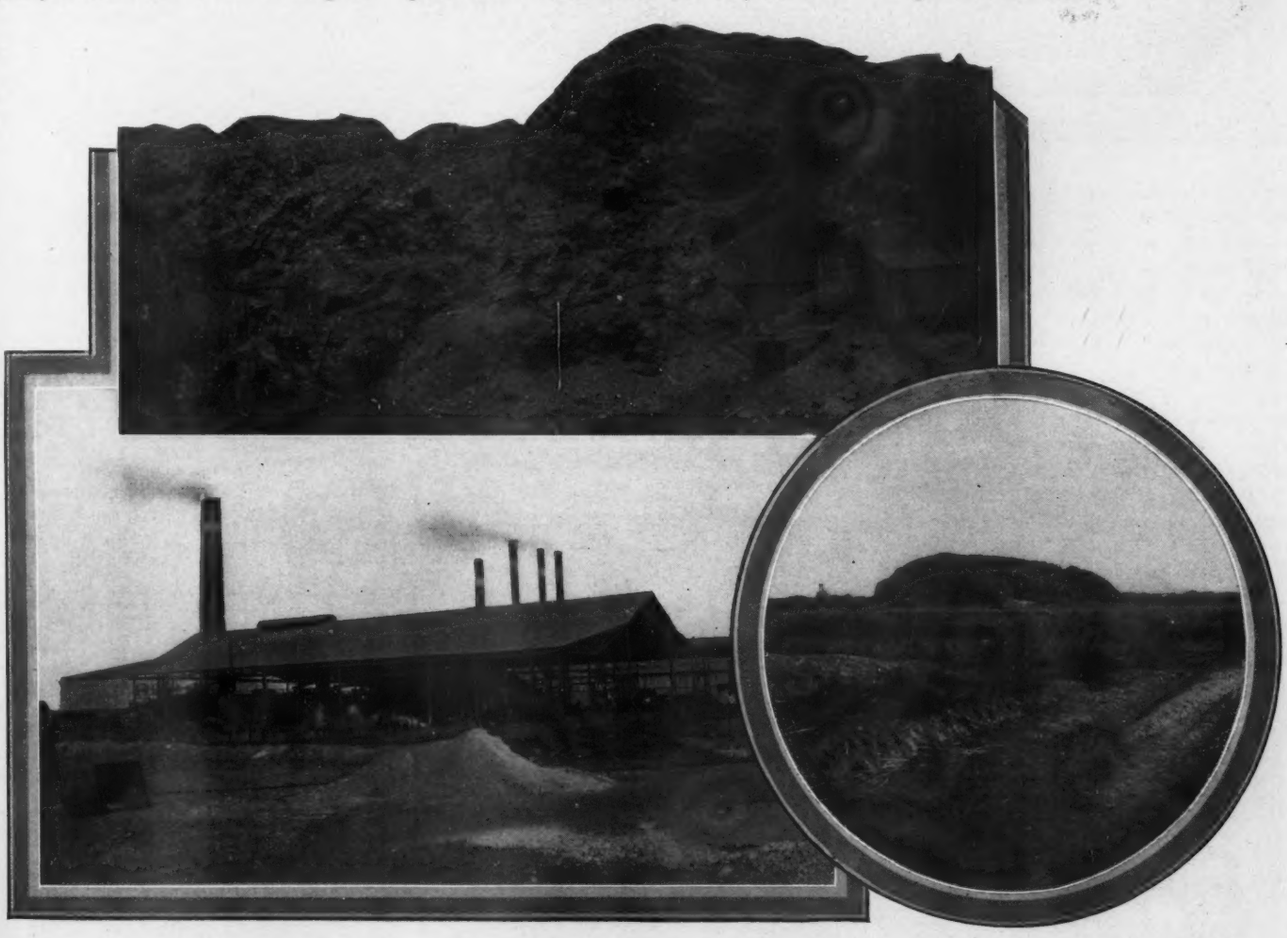
By OWEN LETCHER*

SIX hundred miles north of the Zambesi, where that mystic river thunders over Victoria Falls, the development of one of the richest copper fields in the world is writing another chapter on the palimpsest of Africa. This cupriferous area, which extends for 200 miles and has an extreme breadth of 50 or 60 miles, produced 57,886 tons of metal in 1923; and the ore actually blocked out in the existing reserves has a value of close on to $1,225,000,000. The presumptive reserves are incalculable: there are mountains and mountains of ore. Almost every bare hill in Katanga, as this province of the Congo is termed, is a potential copper mine.

It was by observing the absence of vegetation on these mountains that the lay of the mineral zone was determined by the prospectors who went into the far north at the bidding of Rhodes and his lieutenant, Robert Williams, at the close of the last century, when the northernmost point of the Cape to Cairo railroad was over 1,000 miles away to the south. Those explorers, led by George Grey—brother of Viscount Grey of Falloden—found a mineral belt of surpassing richness; and they ascertained, too, that they were not the first human beings who had delved for the green stones of malachite and chrysocolla in the southern heart of Africa. Great open workings proclaimed the mining activities of the Arab slave-and-ivory regime in Central Africa; and who knows but that long, long before those Asiatic marauders bleached the trail to the East coast with human bones some other race or dominant tribe had mined and smelted copper ore in this highly mineralized region?

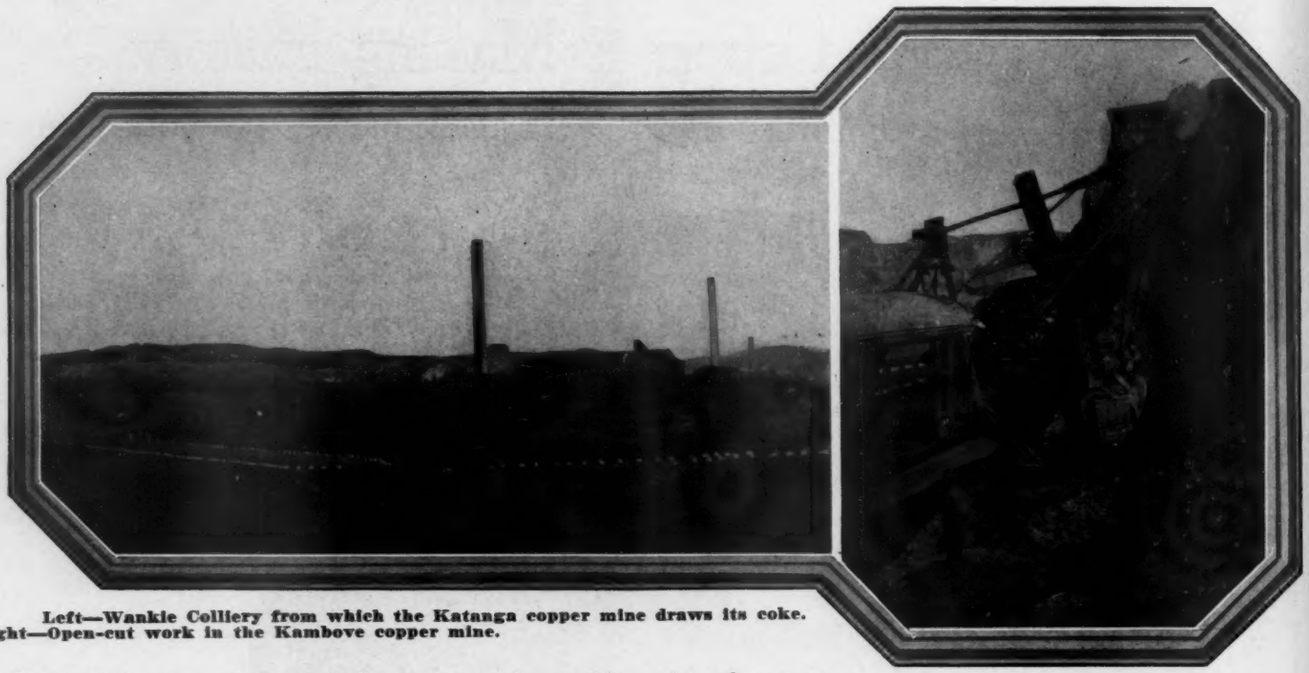
We do know this, at any rate, that a century and a quarter ago Portuguese adventurers traversed this tract and recorded the presence of copper on their journeyings from the Atlantic to the Indian Ocean, and that 60 years later the immortal Livingstone—who urged the world to heal its great open sore, the bartering of bodies and souls driven from their pristine resorts on the great equatorial plateau out to the slave markets of Zanzibar and Bagamoyo—had drawn attention to the extensive copper outcrops which existed on the Congo-Zambesi divide.

Twenty-five years after Livingstone had ended his last journeyings in the little village at the south end of Lake Bangweolo, where now a remote obelisk marks the spot of his heroic passing, Belgian explorers and geologists called the attention of King Leopold to the copper mines of Katanga. By that time this astute monarch of the Belgians had founded the Congo Free State on a basis of international recognition; but, with the railway still no further north than the Cape Colony, Leopold replied that copper in Katanga interested him less than gold in the moon!



Top—Open workings at the Rhodesia Broken Hill lead and zinc mines.
Left—Lead smelter of the Rhodesia Broken Hill Company.
Right—One of the big lead-zinc kopjes of the Rhodesia Broken Hill property.

*Editor, *South African Mining Journal.*

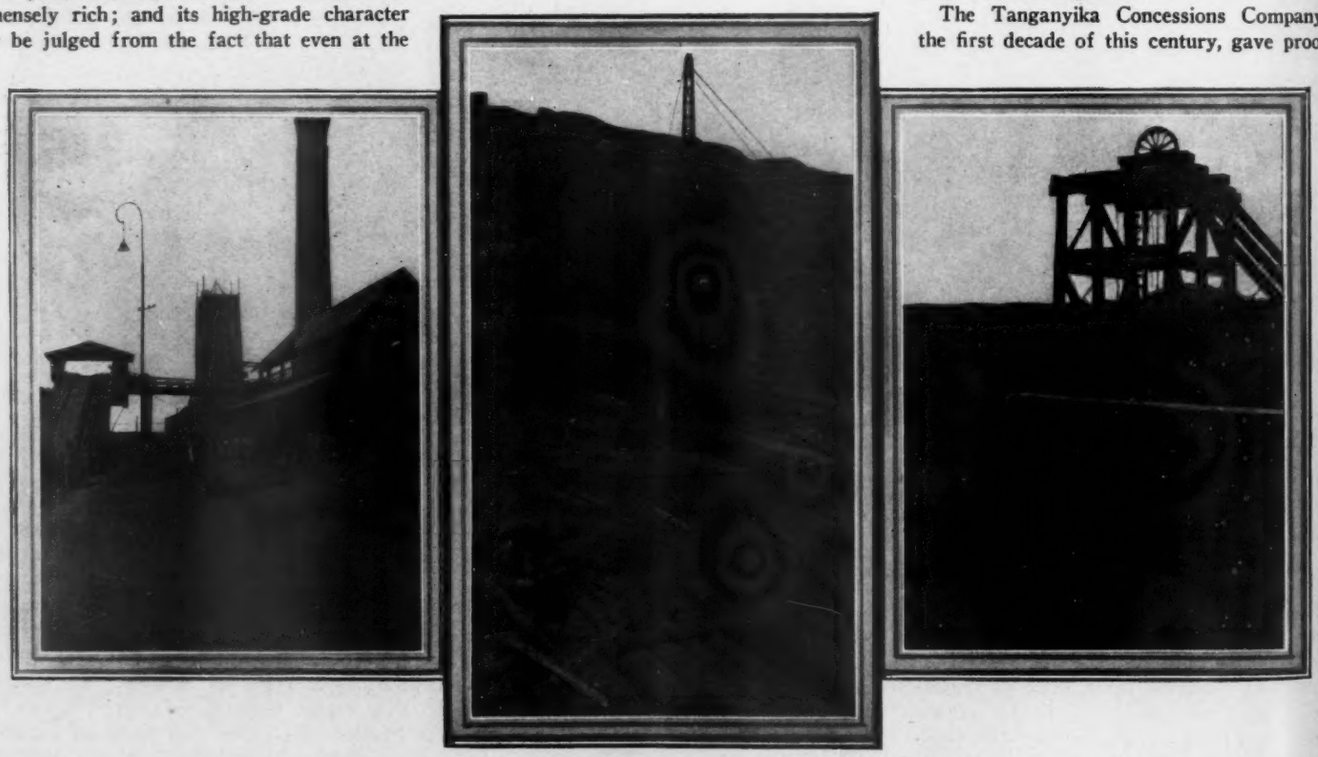


Left—Wankie Colliery from which the Katanga copper mine draws its coke.
Right—Open-cut work in the Kambove copper mine.

During the latter part of the Anglo-Boer War, however, George Grey—who was afterwards killed by a lion in Kenya—led his expedition northward and located the great copper zone not on the British side of the divide, as Rhodes and Williams who had financed the adventure had hoped, but over the frontier in the Belgian state. A company, styled the Tanganyika Concessions, was then formed under agreement with the Congo Government to exploit the mines. American, English, and Australian mining engineers, who had planned the exploitation, reported that the area was immensely rich; and its high-grade character may be julged from the fact that even at the present time anything under an 8 per cent. metallic content is accounted low grade. But in Katanga, as in every other mining field, there are for each rich ton two, three, or perhaps more tons of ore which Nature has not endowed so liberally.

Of this lower grade ore, the Union Minière Company possesses illimitable reserves; and it also has immense actual and presumptive tonnages of ore which are at least four or five times as rich as the reserves of any other large copper mines producing elsewhere. Today, the Katanga properties can be worked only on a high-grade basis because transport problems and metallurgical difficulties render the cost of operation abnormally high. Eventually, the railroad and the treatment questions will be satisfactorily answered, and then it will be possible to realize on the immense tonnages of relatively poor ore. We will deal with this aspect of Congo copper later on. Let us return for a while to the engaging history of the exploitation of the venture in the earlier stages of development.

The Tanganyika Concessions Company, in the first decade of this century, gave proof of



Left—Part of the Lubumbashi smelter of the Union Miniere just outside Elizabethville.
Center—Prospecting cupriferous deposits at Bwana M'Kubwa by means of a diamond drill.
Right—Prospecting shaft at the Bwana M'Kubwa copper mine on the British side of the Congo-Zambesi divide.

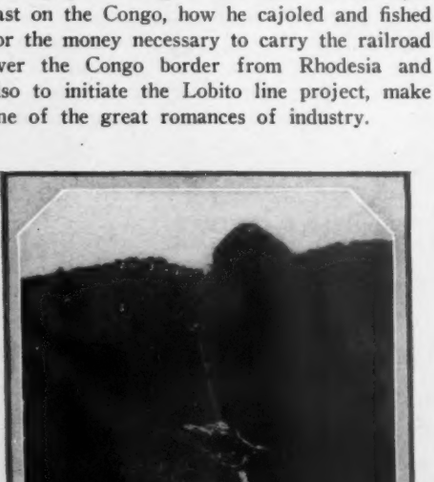
From left to right starting at the top—"Unspoiled" natives on the Congo-Zambesi watershed.
Natives handling copper matte at the Lubumbashi smelter.
Rich ore stacked for transport to the smelter at the Star of the Congo mine.
Open-cut benches at the Kambove copper mine.
The grave of Cecil John Rhodes in the Matopo Hills.
The eternal feminine as she appears in all her allurements in the Belgian Congo.

Two views of Victoria Falls, which the natives call "Mosi-oa-tunya," meaning The Smoke That Sounds.

the immense copper resources of the area and also established the presense of gold, tin, and other minerals in the concessions. Its prospectors had many momentous encounters with wild animals; and tropical disease took its toll of their number when they descended from the plateau into the low-lying valleys of the tributaries of the mighty Congo. But they toiled on; and although in its earlier days the Katanga copper industry was regarded with skepticism it is now generally conceded that a new wonder has come out of Africa in the shape of this mineral industry.

In 1908, under the initial agreement, the concessions acquired and the work done by the Tanganyika Company were taken over by a Belgian concern—styled the Union Minière du Haut Katanga—backed by some of the leading financiers and industrialists of the rich little kingdom. The preliminary exploitation achieved in the pinafore stage of the venture was intensified when a proper development programme, aimed at early production on an increasing scale, was laid down and put into practice under the direction of American and British Engineers. There were, however, many difficulties to be overcome, and these had to do principally with metallurgy and transport. Here was an admittedly large and rich cupriferous field, but situated at a great distance from either seaboard of the continent and not yet linked with the railway which had reached rail head at Broken Hill, in northern Rhodesia, 250 miles to the south in 1906.

In order to secure an economic outlet on the Atlantic seaboard, Robert Williams and his associates had entered into an agreement with the Portuguese to build a line from the copper fields to Lobito Bay, which is situated on the coast of Angola and is one of the most wonderful natural harbors in the world. How Williams parleyed with kings and governments, how he countered the intrigues of a certain other European power which desired a dominant grip on Angola and had envious eyes cast on the Congo, how he cajoled and fished for the money necessary to carry the railroad over the Congo border from Rhodesia and also to initiate the Lobito line project, make one of the great romances of industry.



Mulungushi Falls, in Northern Rhodesia, where the river takes a leap of 1,170 feet into the Luano valley. A power plant is being built at this point.

The full story or even a goodly portion of it would take far too long in the telling here; but suffice it to say that over a dozen years ago the "iron horse" came lumbering into Elizabethville—the capital town of Katanga, a well-laid-out little city with a fair climate and a cosmopolitan population of a few thousand whites and blacks. Since then the railway has been carried on to Bukama, on the navigable Congo River; the Lobito line has been constructed for about half its distance; and a road is being built by the Belgians to link Katanga with the lower Congo basin at Ilebo. Another rail and water route connects the copper belt with Dar-es-Salaam, in Tanganyika territory, on the Indian Ocean; and a certain amount of copper is finding its way out to the markets of Europe by this route. However, the bulk of the Katanga output passes through the port of Beira, in Portuguese East Africa. This railroad haul of over 1,600 miles eats up a great deal of the copper industry's earnings: in point of fact, one half of the total operating charges of the Union Minière Company is made up of transportation costs. The ultimate solution of this problem will lie in freighting the product via the Atlantic route on the west coast.

As concerns the ore-treatment question, the eventual solution of Katanga metallurgy is likely to be found in the employment of a large-scale electrolytic plant. Although that stage has not yet been reached, there are leading metallurgical engineers who have been engaged in working out the details of a scheme for the past two or three years. The consummation of such a project may take a long time; but an experimental plant at Panda, where the Union Minière Company has its

4,000-ton-per-diem breaking and concentration plant, has given satisfactory results. For the time being, copper production is for the most part being maintained and indeed increased by the smelters at Lubumbashi just outside Elizabethville. These smelters are using each month about 11,000 tons of coke obtained from the Wankie colliery situated 68 miles to the south of the world-famous Victoria Falls in southern Rhodesia.

That mighty, natural power-storage house on the Zambesi—Victoria Falls—has not yet given up any of its many daily millions of horse-power to the sub-continent. But the time will no doubt come when the thundering Zambesi will be harnessed in the interests of industry; and, meanwhile, it is worth mentioning that surveys have been made of potential water-power areas at Koni Falls and in N'Zilo Gorge in the Lufira and Lualaba Rivers—the Congo's southern tributaries. Central Africa is, indeed, just waking up to the fact that immense volumes of cheap power are available on either side of the Congo-Zambesi watershed.

Away to the south of Katanga, on the British flank of the divide, there are other copper prospects of which the most important are the Bwana M'Kubwa, N'Kana, and N'Changa. These mines are in charge of Preston K. Horner, an American mining engineer formerly general manager of the Union Minière. Still further south are the great mixed lead, zinc, and vanadium mines of Rhodesia, at Broken Hill; and it may be noted that the operators of these mines are now engaged on the construction of a power plant at the Mulungushi Falls where the river takes a dive of 1,170 feet amidst scenes of surpassing splendor and in a wild region where buffaloes, lions, and leopards still roam around at will. With cheap colored workmen and abundant water power—that is to say, with white coal and black labor—this great base-metal country lying around the headwaters of two of Africa's mightiest rivers may make history during the next few years.

When railroad exit via the west coast becomes available, these workings will be in a position to forward vast quantities of copper, zinc, and lead to the world's metal markets at a comparatively low cost of production. A more topical consideration, however, is the effect which all this industry and dissemination of wealth is having on the native population in this section of Africa. Neither the Belgians in the Congo nor the British in northern Rhodesia maintain any color bar, as is done in the Transvaal. The blacks are being brought into the scheme of industry. They are being taught mechanics, mining, railroad operation, clerking, and all manner of trades and callings in technical schools and under pressure of environmental influence. There are in Katanga, today, black artisans who can strip and reassemble a locomotive or direct a station on the main Cape-Congo Railroad. I have seen them do it; and I have heard them converse freely over the telephone in English, in French, and in several native languages. A decade or so ago these self-same natives were carrying impedimenta for elephant hunters and traders, and they thought the world was bounded by food, water, a hut in the bush, and their women folk. Will this big black civilization, which is being built up in the heart of Africa on the foundation of the base-mineral industry of the Congo-Zambesi watershed, invade and perhaps engulf South Africa with its mixed white and black ideals, or will it be arrested by the Zambesi River which forms the natural boundary between the tropical and the sub-tropical divisions of the southern part of the dark continent? I will not attempt to answer such a question; but it may be said that this problem is engaging a great deal of attention and not a little anxiety in the Union of South Africa at the present time.

To turn for a moment, and in conclusion, to a more practical consideration of the great mineral field with which this article is concerned, is it not of interest to reflect on the large requirements of these mines as regards mining and metallurgical equipment of all kinds? Already, Bucyrus steam shovels are eating up ore in the open workings of the copper area, and American-made air drills are tunneling into the earth. And there is a vast amount of money involved in prospect. The Union Minière's big hydro-electric project is a $50,000,000 scheme. The United States engineering professions have in various ways been closely linked up with these African mineral undertakings in the past. It is probable that they will play a still more important part in the development of this great base-metal zone in the future.

Courtesy, U. S. Forest Service.

Brush-burning torch in action in one of our national forest reserves.

A BRUSH-BURNING TORCH

A PORTABLE torch, such as is now generally employed by the United States Forest Service for burning piles of brush and for back firing, is suitable for railroads, woodmen, lumbermen, farmers, and others who could oftimes use an equipment of this kind to good advantage. This one-man outfit is charged with compressed air and kerosene, which is ignited by a burner held by the operator. The oil container or tank, which is carried knapsack fashion, is made of steel and comes in 1½- and 3-gallon sizes. The burner nozzle is fabricated of a suitable heat-resisting material.

Ordinarily, the Forest Service devotes its energies to combating rather than to starting fires. However, as brush heaps and piles of decaying leaves are not infrequently responsible for serious conflagrations, the use of this torch makes it feasible to dispose of the menace quickly and at a low cost.

©P & A Photos.

At the Brompton Hospital, London, England, compressed air is used for the treatment of bronchial troubles. The patients are placed in a steel cylinder, ten feet high and about six feet in diameter, and subjected to air pressure. The pressure is gradually raised, and then, after a suitable interval, it is lowered to that of the outside atmosphere. In this way, the patients are obliged to breathe larger quantities of curative oxygen than normally.

The first public steam railway in the world, the Stockton & Darlington, was opened to traffic on September 27, 1825, and the centenary of the event is to be celebrated in England. Our Louisville & Nashville Railroad was 75 years old on March 5 of the present year. It was started for the purpose of operating between the two largest cities of the states of Kentucky and Tennessee—later reaching Cincinnati, Ohio, and traversing most of the South, doing much for the coal and steel industries of Alabama.

Courtesy, Southern California Edison Company.

HOLING THROUGH THE FLORENCE LAKE TUNNEL

Fig. 1—Throwing the switch that set off the final blast.
Fig. 2—Loading with dynamite the drill holes at one of the opposing headings.
Fig. 3—Taking out the last of the muck with a steam shovel operated by compressed air.
Fig. 4—One of the X-70 drills which helped to drive this 13-mile tunnel.
Fig. 5—Some of the drill steels used in advancing a heading through hard rock.
Fig. 6—Chipping loose fragments from the tunnel roof after the blast had holed through.

Suggestions on the Care and Use of Rock Drills

By E. R. BORCHERDT and H. D. SULTZER*

PART I

WE all know how discouraging it is to have a machine break down on the last hole or two when rustling another means missing the round and its resultant reduction in the size of the weekly pay check. It is a tough enough job to drag a machine up the rock slide of a rill at the beginning of the shift, but where it is occasioned more than once by machine trouble a lot of time and energy is lost which might have been more profitably expended in drilling a few more holes.

It is imperative that a rock drill, to meet the varied and exacting demands made upon it, should be kept properly lubricated.

In order to reduce production costs and at the same time to give the miner an opportunity to earn more money, the Anaconda Copper Mining Company is sparing no expense to maintain the best and most modern rock drill equipment; and, with this end in view, is supervising the conditioning of drills and drill steel, as well as carrying on a great deal of experimental work with new machines and improving the older types.

The success of this undertaking depends largely on the coöperation of everyone concerned with the handling of the machines; and for the benefit of the miner who unknowingly does something wrong, because he has never been shown the right way, the following remarks are presented. They are, for the most part, based on actual observations of wrong practices which annually result in the loss of thousands of dollars in time lost by miners in transporting machines to and from the working places because of failure of their machines. These remarks do not reflect on the skill of many machine men whose ability is recognized, but it is hoped that they will be of profit to those of limited experience with rock drills.

By far the greatest percentage of trouble is caused by improper or insufficient lubrication. It is only reasonable to expect a machine, striking 1,800 to 2,200 blows a minute, to require plenty of oil between its moving parts. That the oil must be of the proper body for the most efficient operation of the machine is known from experiment which revealed that the use of a heavy-bodied oil may decrease the drilling speed as much as 25 per cent. From this it will be seen that the use of cup grease in the air-inlet spud will cause a considerable falling off in the number of holes drilled in a shift. Introducing grease into the oil reservoir will plug the absorbent cartridge and also the ports leading to the cylinder so that no lubrication will enter the machine. Manufacturers have purposely left a clearance of one and five-tenths thousandths of an inch between the piston and cylinder for a suitable film of oil, the absence of which, through increased friction and leakage of air past the piston, lessens the power of the blow delivered to the steel. You have all noticed that when the rotation sticks, even when the steel is free to turn in the hole, that the addition of a "shot" of oil will frequently remedy the trouble.

The machines are designed to receive ample lubrication from the oil reservoir, but unfortunately this amount is insufficient when the oil is being removed by water getting into the cylinder. In that case, additional lubrication must be supplied every hole or two. The removal of oil by water results in excessive wear in rifle bar and piston and consequent loss of rotation power. A heavy fog coming from the exhaust when the machine is running is a positive indication that water is getting into the cylinder in one of the following ways: If the water tube has been changed in the mine and the back-head plug has not been drawn up tight a few drops of water will continuously leak into the cylinder between the head and the water tube; leakage from a split or damaged water tube; failure to close the water valve before the throttle is turned off;

Robust and skilfully built as a drill of this kind is, the operator can get the best service out of it only by handling it in a workmanlike manner.

*Efficiency Engineers, Anaconda Copper Mining Company.

and leakage through the brass water valve when the seat is worn. Occasionally a "slug" of water may enter the machine from the air line.

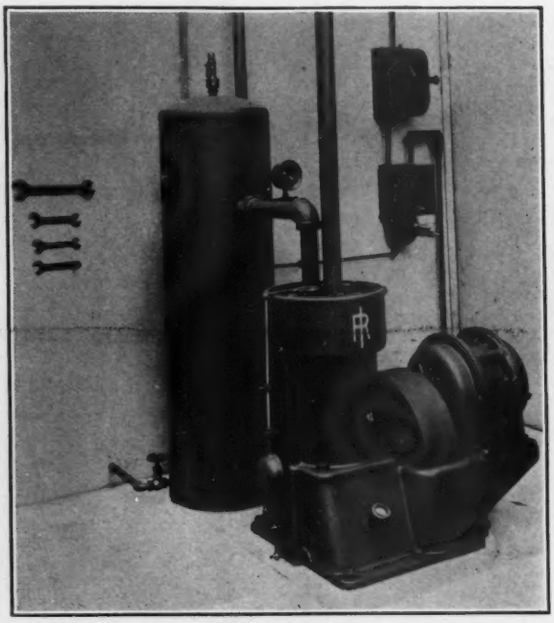
The correct way to control the water valve is to open the throttle partly before opening the water valve, so that when the water gets to the end of the tube the air picks it up and keeps it moving toward the end of the bit. In shutting down, close the water valve first, then allow the machine to idle for ten or fifteen seconds so that the front end of the drill, as well as the steel, will be cleared of water and none will run back into the cylinder. In soft ground this suggestion cannot be followed without incurring danger of plugging the steel. If a water tube must be changed, a new tube rubber should be used and the plug should be drawn up tight. If the plug cap becomes cross-threaded or the copper gasket damaged, water will leak on the feed screw and remove the oil, making cranking difficult. The use of grease on the feed screw to overcome this effect is bad practice, because it retains abrasive particles of rock which grind out the screw and nut.

A majority of the holes in a drift round are drilled with the machine under the arm, in which position it is impossible to fill the oil reservoir and oiling through the hose must be resorted to. At best, this is a poor expedient because, unless the oil is introduced at the line valve end, about 98 per cent. of it is blown out of the machine in the first minute or two of running and the machine will again stick for lack of oil in a short time. On the latest model drifter, provision has been made for filling the lubricator when the machine is under the bar. A lubricator is being developed which, with one filling, will feed a uniform amount of oil through the hose for the entire shift.*

Occasionally, a machine will lack "pep" and exhibit the symptoms of low air pressure. This, it will be found, is caused by the air-filter screen becoming clogged with small pieces of rock and bits of rubber from the inside of the hose. To avoid trouble of this kind, always blow out the hose for half a minute or so with the line valve wide open. Plugging the chuck and spuds with waste or paper before setting the machine aside is good practice. To sum up:

Don't expect your machine to do first-class work without giving it first-class care.

Such a lubricator has been produced by the Ingersoll-Rand Company to meet this requirement.



Type of compressor unit well suited to furnish sufficient air to operate a single nozzle for cleaning mine locomotives.

Use a proper grade of oil and plenty of it, and do not use cup grease in the lubricator, air spud, or feed screw.

Prevent water leakage from removing oil which should reach the moving parts. The chief reason for water leakage is improper placement of the water tube, or the use of defective rubber.

Don't shut off the air throttle completely before shutting off water.

Don't use a leaky brass water valve.

Keep air-filter screen clean, and blow out hose thoroughly before making any connection.

Keep side rods tight and even.

Run on half throttle when holding back on crank.

Always remove machine to place of safety after use so that it will not be injured by blasting or falling rock.

In striking your steel, be careful not to hit the machine.

(To be continued)

Reprinted by courtesy of The Anode.

Iquitos, Peru, which is on a tributary of the Amazon, is 2,300 miles from the sea and is the farthest point inland that can be reached by ocean-going craft. Callao, Peru, a well-known seaport on the west coast, is only 500 miles to the south and west of Iquitos, but impassable mountains lie between. Recently, a cargo of valuable hardwood was taken from Iquitos by steamer down the Amazon, up around South America, through the Panama Canal, and then down the coast to Callao—a total distance of 5,500 miles which necessitated crossing the equator twice. Even at that, the canal offered a route 3,500 miles shorter than that around Cape Horn.

AIR USED DAILY TO CLEAN MINE LOCOMOTIVES

THE motor equipment of a mine locomotive can be made dustproof, but it is a difficult matter to design, for locomotive use, a resistor that will be dustproof and at the same time able to successfully dissipate the heat. The resistor, we might explain, is used to limit the amount of current supplied to the motors, thus increasing or decreasing the speed or pulling power of a locomotive. Current passing through the resistor generates a considerable amount of heat, and therefore makes enclosed construction something of a problem. Accumulations of dirt in an open-type resistor is often the cause of electrical troubles. Breakdowns and delays, however, can be prevented by cleaning at frequent intervals. This may be done quickly and with but little effort by a jet of compressed air.

One of the accompanying illustrations shows a regular afternoon performance at a large West Virginia Coal Mine where each locomotive is thoroughly cleaned every day before being taken to the barn. The other picture shows an efficient self-contained outfit for supplying air for this purpose. The compressor is just large enough to provide sufficient air to operate a single nozzle; and a mine so equipped can do all manner of cleaning even though the regular mine compressor be shut down for one reason or another.

Courtesy Coal Age.

A mine locomotive undergoing its daily cleaning with compressed air.

A FEW OF THE MANY SHOP USES OF AIR-DRIVEN TOOLS

Fig. 1—Pneumatic grinder dressing up end of a connecting rod after welding.
Fig. 2—Air-motor hoist serving a forging press.
Fig. 3—Close-quarter type of air drill reaming holes in a large machine part.
Fig. 4—Small pneumatic drill used in drilling holes in steel window frames.
Fig. 5—Compressed air operated hoist lifting heavy parts in loading shop trucks.

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EDITORIALS

LOS ANGELES MUST GO FAR AFIELD FOR MORE WATER

THAT wonderfully productive region of sunshine, fruit, flowers, and succulent vegetables—the southern section of California, is now face to face with a pressing problem because of these allurements and the notable fertility of its soil. From a thinly populated region three and a half decades back, many hundreds of thousands have since been drawn to this land of plenty and climatic charm; and with this growth of population and the intensive cultivation of the soil has come a demand for a vastly increased water supply.

The spectacular story of what Los Angeles did to tap a remote mountain stream to obtain water for her rapidly augmenting citizenry is an engineering chronicle filled with many thrills. The city authorities, after obligating themselves to an outlay of $25,000,000, believed that they had solved their water problem for a generation or more to follow, but they failed to grasp the appeal which Los Angeles would make to the homeseeker and to industry. In 1890 Los Angeles had a population of 50,395, while today she has within her gates probably not fewer than 700,000 persons. Similarly, neighboring communities have come into being or have gathered in numbers; and this has latterly made it imperatively evident that steps must soon be taken to draw water in large volumes from other sources of supply.

The physical situation has made it clear that Los Angeles cannot turn to streams fed by melting snows on the high slopes of the Sierras. She must go much farther afield if she is to have at her command a reasonably uniform and continuous flow of water to her near-by reservoirs. The only waterway that promises to meet these requirements is the muddy Colorado, which forms the southeastern boundary between California and Arizona.

Tentative plans, at least, have been prepared looking to this solution of the problem which concerns not only Los Angeles but other communities in that part of the state. The aqueduct would have a total length of approximately 250 miles. In the course of its journey, the water would have to be raised to an elevation of something like 1,400 feet above the point of intake and travel through threescore miles of tunnels driven through interposed mountain ranges. Once more the rock drill is counted upon to do amazing work in achieving engineering marvels in California.

LONG-RANGE FORECASTING OF WEATHER

TAKING it by and large, the best the weather man can do now is to prophesy what the skies hold for us in the course of the next 24 hours. This answers reasonably well for ordinary requirements; but scientists are agreed that there is room for improvement and that the forecaster should be able to predict what the weather is likely to be a number of days hence. In fact, something of the kind has been accomplished in certain localities where the daily fluctuations in the barometer, week in and week out, range up and down with pronounced uniformity.

Solar radiation is fundamentally responsible for both seasonal and for daily temperature changes and, incidentally, for those atmospheric disturbances that cause the winds to shift and that give birth to the cyclone and to the tempest. Depending upon where and to what extent the sun's rays cause the atmosphere to "boil," breezes are created or storm centers are born which may move forward with vigor or with violence. As a reflex we have rain, snow, or hail when cold currents of air meet warm currents of air laden with moisture.

Dr. CHARLES G. ABBOT, director of the astrophysical observatory of the Smithsonian Institution, will head an expedition that will make a world-wide circuit for the purpose of measuring the daily heat of the sun during a period of four years. An instrument devised by the late Dr. Samuel P. Langley and perfected by Doctor Abbot will be used to detect and to register the slightest alteration in the sun's radiated heat. In this way, thousands of readings will be obtained and tabulated, and the local effects of these changes upon the weather will be evaluated. Further, data will be gathered which may reveal how these seemingly local variations lead to reactions elsewhere and at considerable distances. By closely observing the solar heat simultaneously at many terrestrial points, facts may be developed by which to build up a chain of weather probabilities that will span far-flung regions. Thus it may be found feasible to predict the weather over much longer periods than is now generally the case.

AMERICAN CAPITAL ABROAD

BEFORE the World War, American investments abroad did not aggregate more than $2,000,000,000. Today, American capital in foreign countries has nearly reached a total of $10,000,000,000. Incidentally, it is significant to recall that these investments do not include our governmental war loans.

According to THEODORE R. GOLDSMITH, of the United States Bureau of Foreign & Domestic Commerce, the total of something more than $9,000,000,000 may be divided broadly into two groups of investments: the first, amounting to about $5,500,000,000, representing investments in projects owned and controlled by American capital; and the second, amounting to $3,500,000,000, consists of private loans to foreign governments and foreign municipalities. These figures, so we are informed, do not include foreign investments made during the first quarter of 1925, the par value of which aggregates $279,000,000.

While the financier considers these loans mainly in the light of fiscal transactions, representing an annual return to American investors of fully $650,000,000, still these investments may just as properly be considered evidence of our faith in the stability of the peoples directly benefited and very substantial proof of our abundant good will towards the rest of the world.

USE OF ELECTRICITY GROWS APACE

AMERICAN consumers paid during the year gone a tidy matter of $1,335,100,000 for current furnished them by public-service central stations. This was $65,550,000,000 more than the public paid for its electricity from the same sources during 1923.

In order to meet the ever-growing demand for current, the electric utility industry has planned to spend $578,000,000 during the present year, and most of this money will be devoted to constructing distributing systems and to extending transmission lines. That is to say, $315,000,000 will be devoted to these purposes. Of the remaining $263,000,000, the sum of $168,000,000 will be used in adding to existing steam-driven generating stations while $95,000,000 will be spent on hydro-electric plants.

The significant phase of these activities is the very considerable amount of money which will be employed in interconnecting the transmission lines of hitherto separate systems. It is this interlinking that is gradually bringing about the creation of widespread superpower zones whereby local surpluses of energy can be turned into trunk lines for delivery to distant communities where the immediate facilities are unequal to the peak demands. This makes for operating efficiency and for economy—reducing to just that extent the overhead burden of idle power units.

SOUTH AMERICA A LAND OF PROMISE

A NOTED Canadian banker, SIR HERBERT S. HOLT, recently remarked upon his return from our neighboring continent: "Not more than one per cent. of the people of the United States and of Canada has a proper understanding of the peoples of South America. Relatively few of us here in the north appreciate the tremendous possibilities that exist there today or are aware of the progress that has already been effected."

Almost at the same moment, Gen. JOHN J. PERSHING made this statement: "In South America, there has begun a new era—one of laws and not of men. In the next fifty years we shall find the opportunity to do for that country what foreign capital did for this nation in the first fifty formative years of our history. Nowhere else in the world are more promising investments to be found and nowhere else will our aid be better appreciated."

There are wise men of business and others equally enlightened that have long been conscious of the opportunities for reciprocal service that exist north and south of the equator; but the pronouncements of SIR HERBERT HOLT and GENERAL PERSHING will carry this knowledge to a wider circle—in short, help to bring the two great sections of the western hemisphere to that mutuality of regard and understanding which is so much to be desired.

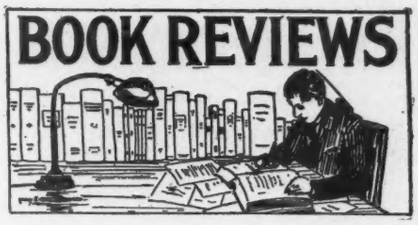
CHINA'S INDUSTRIAL OUTLOOK

CHINA'S wealth lies in her natural resources, according to K. H. DAME of the Far Eastern Division of the United States Bureau of Foreign & Domestic Commerce. Although primarily an agricultural country, rapid strides have been made in the development of her native industries and resources. With huge stocks of coal, iron ore, and an abundance of man power, China has the essentials for the making of a great industrial nation.

The foreign trade of the Flowery Kingdom has shown a steady and a pronounced increase since 1898 in spite of the many adverse factors affecting the transaction of business. In 1898, the total foreign commerce of the country aggregated 368,616,483 haikwan taels, while in 1923 it amounted to more than four times as much. About 73 per cent. of the exports consist of agricultural products; and in the growing of these 80 per cent. of the Chinese people are engaged.

The World War acted as a stimulus to the development of China's native industries and natural resources, and today that country is going through the same process that every great industrial nation has encountered. It needs only the establishment of modern methods of production and adequate transportation facilities to make fuller use of them.

William L. Saunders, President of Compressed Air Magazine, has been awarded the honor cup of the University of Pennsylvania that is given each year to the most distinguished alumnus. Mr. Saunders was graduated from the institution in 1876.



BEACON LIGHTS OF SCIENCE, by Theo. F. Van Wagenen. An illustrated book of 444 pages, published by Thomas Y. Crowell Company, New York City. Price, $3 net.

THIS volume is a survey of human achievement from the earliest recorded times down to yesterday, and the successive though necessarily brief stories are sufficiently comprehensive to give a bird's-eye view of many of the amazing things which have been done in the name of science. As has been well said, "Science is not merely an array of facts; it is a living record of human progress." Mr. Van Wagenen's book brings to a focus the outstanding beacons of this onward march from the days of Phales down to the present in which Edison, Curie, Marconi, Einstein, and others are figuring.

HENDRICKS COMMERCIAL REGISTER. A volume of 2,522 pages published by S. E. Hendricks Company, Inc., New York City. Price, $12.00.

THIS is the 33rd edition of this well-known business reference book. It actually represents nearly 35 years of painstaking endeavor to serve industrials that wish to purchase in the most efficient and economical way. The register has long enjoyed an enviable reputation among men who buy or who specify in manufacturing or jobbing concerns as well as among contractors, architects, engineers, and others.

YEARBOOK AND DIRECTORY OF THE SOUTH AFRICAN MINING & ENGINEERING JOURNAL. A book of 242 pages, copiously illustrated, published by the South African Mining & Engineering Journal, Johannesburg. Price, 10½ shillings.

THIS annual is a valuable reference book of the progress and the industrial activities in that part of the world; and the subjects dealt with are treated with informative fullness. The current volume maintains the high standard which has marked this yearbook heretofore, and it should be useful to anyone interested in mining and engineering in Africa.

BUSINESS LETTER PRACTICE, by John B. Opdycke. A work of 429 pages, published by Isaac Pitman & Sons, New York City. Price, $2.50.

THIS new and revised edition should be welcome to all those people in business that are making an earnest effort to improve the letters turned out either by themselves or their office associates. Among other things this volume is intended, so we are informed, to serve in bringing teachers of stenography and teachers of English in commercial schools and colleges into closer and more sympathetic coöperation. Experience all to frequently reveals an absence of this coöperation as evidenced by the deficiencies in English of the great rank and file of stenographers; and in a busy business office few maturer minds are available to give that training which the stenographer should have before seeking a job.

This book will be found helpful in the business office by the correspondence supervisor in that office. In short, it should be of service to all those departments in business that are called upon to use letters both for the dissemination of information and instruction or for the promotion of sales.

THE TEXAS ALMANAC AND STATE INDUSTRIAL GUIDE for 1925. A book of 432 pages, with a map, published by The Dallas News, Dallas, Tex. Price, $0.50.

ONE unfamiliar with all that Texas has to offer can get a full and comprehensive idea of the wealth, the progress, and the industrial magnitude of the state after even a cursory glance over the crowded pages of this almanac. We commend it to our readers seeking information about this, the largest of our states.

THE United States Bureau of Mines, Washington, D. C., has recently announced the following new publications:

BULLETIN 190. *Coal-Mining Problems in the State of Washington,* by G. W. Evans. 1924. 79 pp., 7 pls., 34 figs.

BULLETIN 233. *Protection of Oil and Gas Field Equipment Against Corrosion,* by R. Van A. Mills. 1924. 127 pp., 20 pls., 20 figs.

TECHNICAL PAPER 322. *Experiments in the Use of Back Pressures on Oil Wells,* by T. E. Swigart and C. R. Bopp. 1924. 66 pp., 5 pls., 4 figs.

TECHNICAL PAPER 352. *Detection of Small Quantities of Petroleum Vapor with the Burrell Methane Indicator,* by G. W. Jones and W. P. Yant. 1924. 19 pp., 1 pl., 4 figs.

TECHNICAL PAPER 374. *Accidents at Metallurgical Works in the United States during the Calendar Year* 1923, by W. W. Adams. 31 pp.

In a paper on tar distillation, read before the London Section of the Society of Chemical Industry, incidental mention was made of a simple method for breaking up pitch. In the process of manufacture, the heated pitch is allowed to discharge into a bay on the floor of which loose chains are spread. When the pitch has cooled and solidified, the chains are hauled up by a traveling winch—thus breaking up the mass in pieces suitable for handling.

The United States Patent Office has latterly been transferred to the Department of Commerce, under Secretary Hoover. When originally created, in 1790, it was attached to the Department of State; but since 1849 it has been a part of the Department of the Interior.

THE Staynew Filter Corporation has enlarged its manufacturing plant at Rochester, N. Y., and appointed several new distributors and dealers. This company makes "Protectomotor" air filters for automotive vehicles and for air compressors.

By means of a simple attachment—devised by the Staynew Filter Corporation—engineers and others can make their own tests, it is said, and thus satisfy themselves as to the correctness of the claims made for "Protectomotors."

LEAD FILINGS MAKE TIGHT PIPE JOINTS

A HEATING contractor recently informed the United States Bureau of Standards that he had found that lead filings, sprinkled on the threads of piping, gave a tighter joint than when ordinary white or red-lead paste was used. The filings were made with a coarse rasp from a piece of lead pipe and were held in place by the cutting oil that remained on the threads.

As the method was new to the bureau it was decided to make test joints of white-lead paste, of lead paste and lead filings combined, and of lead filings only, for the purpose of ascertaining the relative merits of these different methods. The piping used was of ½-inch diameter; and the joints were tightened as nearly as possible to the same degree.

These joints were allowed to set for a week and were then tested under water pressure which could be raised to 8,500 pounds per square inch. Half of the lead-paste joints leaked below that pressure—one failing at 1,050 pounds per square inch. One of the combined paste-and-lead-filing joints leaked at 3,900 pounds pressure, while those in which lead filings alone were used uniformly withstood the full pressure of 8,500 pounds without leaking.

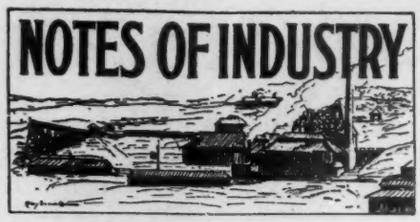
The force required to unscrew the joints was also measured. While it took more energy to unscrew the straight lead and the lead-and-paste joints than those made of paste, it should be borne in mind that the paste was still relatively fresh—not having had a chance to harden sufficiently. The lead joints all unscrewed readily; and it is obvious that time will not affect the straight lead joint as much as it would the paste joint. In short, the tests proved the lead-filing joints to be decidedly superior.

TO EXTRACT BROMINE FROM THE OCEAN

BROMINE does not occur in nature in an uncombined form and therefore requires chemical manipulation for its production. It has become more or less essential to modern chemical operations, in the manufacture of dyes, in medicine, etc., but the present supply is not equal to the demand.

To relieve the situation, the steamer *Ethyl* has been chartered by the American Chemical Society for the purpose of extracting bromine from the waters of the ocean. One pound of bromine is contained in about 7 tons or 1,700 gallons of sea water; and with an unfailing supply of the raw material to work on, it is evident that the enterprise can find continuous employment.

The Connaught Tunnel of the Canadian Pacific, through McDonald Mountain of the Selkirk Range, is now lined with concrete twelve inches thick throughout its entire length of five miles. According to C. A. Cotterall, in charge of construction, nearly 1,000,000 sacks of cement were used in the work, which was done by means of compressed air.



The production of cement in the United States during the first eleven months of 1924 amounted to 138,424,000 barrels, as compared with 127,380,000 barrels for the same period in 1923. At the present rate, last year's output bids fair to exceed that of 1923—the largest in the history of the industry.

A decade ago a few lumber schooners served to handle all the commodities carried by water to and from Los Angeles, Calif. Today, thanks to the Panama Canal, 126 steamship companies make it a port of call. Last year a total of 5,600,000 tons of freight was transported by water from Los Angeles to Baltimore, Philadelphia, and New York.

A large amount of lead goes into the making of electrical cables used for one purpose or another. For instance, in the United States there are today about 82,000 miles of telephone, telegraph, radio, and electric-light cables protected by a covering of 327,300,000 pounds of lead.

A laboratory for radium research, with special reference to the study of the chemical effects of radium radiations, has been established in Washington, D. C., under the direction of the chief of the division of mineral technology. Hitherto, this work has been conducted at the rare and precious metals experiment station located at Reno, Nev.

It is conservatively estimated that road dust, grit, and carbon cost the motorists of the United States more than $350,000,000 annually for replacing pistons, rings, and bearings; that 600,000,000 gallons of gasoline are wasted each year by reason of worn motors; and that 10,000,000 machines are idle in repair shops an average of five days each twelvemonth.

Contrary to the popular idea, the Chinese are not all rice eaters: there are millions of them in North China, including Manchuria, that consume little rice. The people of those districts produce wheat, millet, corn, beans, and sweet potatoes, and these products constitute the main part of their dietary. In other parts of China the demand for wheat flour is constantly increasing.

A special train made up of twelve cars to carry a pipe organ and its associate parts! This sounds like a pipe dream; but the mammoth organ recently finished for Roosevelt Memorial Park, Los Angeles, Calif., by the Rudolph Wurlitzer Manufacturing Company, at North Tonawanda, N. Y., actually needed that number of cars to assure its safe transportation to the Pacific coast.

Both the French and the Germans have developed processes by means of which a wool finish can be imparted to cotton fabrics. It is reported that cotton cloth so treated not only appears but feels like woolen goods, and that these qualities remain after washing. All kinds of cotton goods may be treated by the process, but the best results are obtained with loosely woven materials.

Despite the fact that the culture of tobacco in Egypt is forbidden by law, that country has a large cigarette-manufacturing industry which depends on foreign sources for its supplies of tobacco.

A new anthracite seam is reported to have been discovered in the vicinity of Belmont, Nova Scotia, according to an article in the *Halifax Herald*. Final tests as to the quality of the coal have not yet been made, but it is believed to be of a grade to justify working.

An American concern has built a searchlight of 1,200,000,000 candle power. This light is able to pierce the sky at night and to pick out an airplane in good weather at a distance of 30,000 feet—nearly 5.7 miles away. The searchlight weighs only 1,500 pounds, and by reason of this it can be readily moved from point to point.

Genoa, formerly the leading port of Italy and the second in importance on the Mediterranean, has outranked Marseilles and is now the premier port on the Mediterranean.

Metallic magnesium is now being used for the rotors of centrifugal air compressors which serve as superchargers on aircraft engines—its adoption being dictated by reason of its lightness. The stresses on the blades of these rotors are directly proportionate to the weight of the blades; and the specific gravity of magnesium is only about two-thirds that of aluminum. Even though the tensile strength of magnesium is less than that of aluminum, magnesium affords a decidedly greater factor of saftey.

A million dollar sugar plant is being erected at Raymond, Alta., and will be ready to slice beets by next October. Six thousand acres of beets, with a production of from 70,000 to 90,000 tons, have been contracted for with farmers in southern Alberta.

The City of Haifa has been selected by the government of Palestine as the place best adapted for the construction of a port.

The Ontario government has definitely decided to start construction on the 37-mile extension of the Larder Lake branch of the Temiskaming & Northern Ontario Railway into the Rouyn gold fields. According to present plans, the spur is to be completed by December 1, 1925, and will cost about $1,750,000. The decision to extend the line followed close upon an agreement made by the operators at Rouyn to build a smeltery there as soon as steel reached the camp.